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MICHIGAN STATE COLLEGE
AGRICULTURAL EXPERIMENT STATION
EAST LANSING

THE QUARTERLY BULLETIN

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.

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MICHIGAN STATE COLLEGE
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EAST LANSING

C. M. HARDIN, DIRECTOR
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MICHIGAN 350 AND MICHIGAN 250—TWO NEW CORN HYBRIDS FOR MICHIGAN[1]

By E. C. ROSSMAN, E. E. DOWN, and R. E. DECKER
DEPARTMENT OF FARM CROPS

TWO NEW EARLY maturing corn hybrids were released in 1951 by the Michigan Agricultural Experiment Station for seed certification. These two hybrids are Michigan 350 and Michigan 250. Certified seed will be available to Michigan farmers for planting their 1952 corn crop. Double-cross seed for Michigan 350 and Michigan 250 was produced in 1951 on approximately 360 and 90 acres, respectively, by members of the Michigan Crop Improvement Association.

CHARACTERISTICS OF THE NEW HYBRIDS

In the following discussion the characteristics of Michigan 350 and Michigan 250 are compared with those of other Michigan certified hybrids. The information is based on the results of 50 over-state corn trials conducted during the 4-year period 1948-51. Extension Folder F-67 (revised), *Corn Hybrids Compared,* presents results of comparisons with other hybrids.

Table 1 gives the average performance by years for each of the four years of over-state testing and the average performance for all years. Yields are reported on a uniform basis as bushels of shelled corn at 15.5-percent moisture; moisture content is given as the percentage of moisture in the ear (cob plus grain); "stalk lodging" refers to the percentage of plants broken over below the ear; and "root lodging" is the percentage of plants leaning at an angle of 30 degrees or more from the vertical. These results were obtained from trials conducted in 16 counties, and the average corn yields ranged from approximately

[1]A grant from the Michigan Certified Hybrid Seed Corn Producers' Association helped to finance this study.

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20 bushels per acre to more than 100 bushels, depending upon soil and weather conditions. Interactions of hybrids with locations and seasons were generally negligible, indicating that these hybrids tended to respond in the same relative manner regardless of location or season.

TABLE 1—Performance of Michigan 350 and Michigan 250 in comparison with other certified hybrids during 1948, '49, '50, and '51, and the four-year average performance

Hybrid	Year	Number of trials	Yield in bushels per acre	Moisture in ears, percent	Stalk lodging, percent	Root lodging, percent
Michigan 250.....	1948	3	59.9	28.0	2.6	—*
Michigan 11A....	1948	3	47.9	25.9	5.6	—
Michigan 350.....	1948	3	65.2	30.0	0.9	—
Michigan 51B....	1948	3	54.9	30.7	3.6	—
Michigan 36B....	1948	3	56.8	32.1	3.4	—
Ohio M15.....	1948	3	61.6	34.9	0.9	—
Michigan 250.....	1949	13	73.5	23.8	6.1	—
Michigan 11A....	1949	13	61.1	25.1	10.3	—
Michigan 350.....	1949	13	81.7	27.2	8.6	—
Michigan 51B....	1949	13	66.2	27.5	14.6	—
Michigan 350.....	1949	9	89.2	26.0	8.0	—
Michigan 36B....	1949	9	76.7	29.2	8.0	—
Ohio M15.....	1949	9	81.0	29.6	6.8	—
Michigan 250.....	1950	18	62.9	28.2	4.4	2.2
Michigan 11A....	1950	18	57.2	29.8	10.5	2.1
Michigan 350.....	1950	18	70.7	30.8	6.1	3.7
Michigan 51B....	1950	18	61.6	31.5	9.9	6.7
Michigan 350.....	1950	4	74.1	32.1	3.6	2.8
Michigan 36B....	1950	4	67.1	36.3	6.2	5.6
Michigan 350.....	1950	13	70.4	29.9	6.8	4.3
Ohio M15.....	1950	13	62.5	34.3	5.8	10.3
Michigan 250.....	1951	16	65.7	31.2	4.2	5.1
Michigan 11A....	1951	16	58.4	34.2	11.0	10.5
Michigan 350.....	1951	16	68.5	36.0	6.5	9.2
Michigan 51B....	1951	16	61.4	35.6	10.4	12.7
Michigan 350.....	1951	8	74.5	34.6	2.3	8.4
Michigan 36B....	1951	8	68.3	38.1	4.2	17.7
Michigan 350.....	1951	11	72.3	32.5	8.1	7.8
Ohio M15.....	1951	11	66.4	34.8	8.8	11.5

*No root lodging occurred in the 1948 and 1949 trials.

(Summary of Table 1 on page 203)

TABLE 1 (cont'd)—Performance of Michigan 350 and Michigan 250 in comparison with other certified hybrids during 1948, '49, '50, and '51, and the four-year average performance

Hybrid	Year	Number of trials	Yield in bushels per acre	Moisture in ears, percent	Stalk lodging, percent	Root lodging, percent
Michigan 250.....	4-yr. av.	50	66.1	28.3	4.6	3.1
Michigan 11A....	4-yr. av.	50	58.0	30.1	10.2	4.9
Michigan 350.....	4-yr. av.	50	72.3	31.6	6.6	5.4
Michigan 51B....	4-yr. av.	50	62.2	32.0	10.9	8.6
Michigan 350.....	4-yr. av.	24	79.1	30.3	4.4	10.2
Michigan 36B....	4-yr. av.	24	70.0	33.6	5.9	20.9
Michigan 350.....	4-yr. av.	36	74.6	29.9	7.1	5.4
Ohio M15.....	4-yr. av.	36	67.4	33.8	6.7	10.7

Table 2 presents individual comparisons of several sets of two hybrids to show the number of times that the one hybrid excelled the other in each characteristic. In a majority of the trials, Michigan 350 and 250 excelled the other hybrids in almost every characteristic. In

TABLE 2—Comparisons of several certified hybrids. (The numbers in columns 3-6 refer to the number of trials in which the particular hybrid excelled the other hybrid with which it was compared.)

Hybrid	Number of trials	Higher yielding	Drier in moisture	Less stalk lodging	Less root lodging
(1)	(2)	(3)	(4)	(5)	(6)
Michigan 250.....	50	43	42	44	8
Michigan 11A.....	50	7	7	5	4
Equal.....	.....	.....	1	1	3
Michigan 250.....	50	42	48	42	13
Michigan 51B.....	50	8	2	8	1
Equal.....	.....	.....	.....	.....	1
Michigan 350.....	50	43	25	41	12
Michigan 51B.....	50	7	16	9	3
Equal.....	.....	.....	9	.....	.....
Michigan 350.....	24	21	23	14	6
Michigan 36B.....	24	3	1	6	1
Equal.....	.....	.....	.....	4	.....
Michigan 350.....	36	27	35	15	8
Ohio M15.....	36	9	1	20	2
Equal.....	.....	.....	.....	3	1

occasional trials the new hybrids were inferior in some characteristic, but those instances were in the minority. It is generally expected that any one hybrid may not be outstanding in all cases.

MATURITY AND ADAPTATION

Michigan 350 has about the same relative maturity as Michigan 51B; they are both in the "90-day" relative maturity group. Although it tassels and silks 3 days later than Michigan 51B, Michigan 350 matures rapidly and by harvest time the ears are as dry or drier than those of 51B. It is about one week earlier than Michigan 36B and Ohio M15. Michigan 350 has a wide range of adaptation in Michigan. It is well suited for grain production in the northern and central portions of the state where 51B can be expected to mature. In spite of its relative earliness, Michigan 350 has produced excellent grain yields in more southern portions of the state where later maturing hybrids are usually grown. Tests conducted at the Michigan State College muck experimental farm in Clinton County indicate that it is well adapted for muck soil in central and southern Michigan.

Michigan 250 and Michigan 11A are about equal in maturity; they are in the "85-day" relative maturity group. Even though Michigan 250 tassels and silks 3 or 4 days later than Michigan 11A, its ears have been drier at harvest time. It is approximately 1 week earlier in maturity than Michigan 51B and Michigan 350. It should be grown in preference to Michigan 350 where the earlier maturity is needed. Michigan 250 is adapted to areas in northern Michigan where Michigan 11A has been grown successfully.

Leaves and husks of Michigan 350 and 250 remain green longer than those of Michigan 51B and 11A in respective comparisons. This may lead one to believe that the former are later in maturity, but examination of the ears and moisture determinations have shown that Michigan 350 is about equal to 51B in maturity and Michigan 250 is about equal to 11A in maturity.

Periodic sampling at approximately 1-week intervals during the period when the ears were maturing and drying from 60-percent moisture to 20-percent showed that the grain of Michigan 350 reached maximum dry weight (maturity) about the same time as Michigan 51B and the grain of Michigan 250 reached maximum dry weight about the same time as Michigan 11A.

YIELDING ABILITIES

In four years of over-state testing in comparison with other Michigan certified hybrids, Michigan 350 has averaged 16.2, 12.9, and 10.8 percent more dry corn an acre than Michigan 51B, Michigan 36B, and Ohio M15, respectively. It has yielded more than Michigan 51B in 43 out of 50 trials, more than Michigan 36B in 21 out of 24 trials and more than Ohio M15 in 27 out of 36 trials. Compared with Michigan 250, its yield has been 9.3 percent higher.

Michigan 250 has given 14.0 percent more corn than Michigan 11A and 6.3 percent more than Michigan 51B. It has produced more corn an acre than Michigan 11A in 43 out of 50 trials and more than Michigan 51B in 42 out of 50 trials.

For silage, Michigan 350 and 250 generally produce more stalk and leaf growth than Michigan 51B and 11A. Larger production of forage combined with greater grain yields indicate that these two hybrids may be better suited for silage than Michigan 51B and 11A.

LODGING RESISTANCE

Stalk and root lodging resistance of the new hybrids is superior to that of other certified hybrids of the same or later maturity. Michigan 350 has been more resistant to stalk breaking than Michigan 51B and 36B. It has been about equal to Ohio M15 in resistance to stalk lodging. Where root lodging occurred, Michigan 350 was superior to all three of the other hybrids.

Michigan 250 has had less stalk and root lodging than Michigan 11A, 51B, or 350.

MECHANICAL HARVEST

In harvest of strip plantings with mechanical corn pickers, the two new hybrids have generally picked cleaner than Michigan 11A and 51B. They have been about equal to Ohio M15 in this respect. Ear and husk characteristics of Michigan 350 and 250 indicate that they are well suited for mechanical harvest.

SHELLING PERCENTAGE

The shelling percentage for Michigan 350 has been 2.8, 1.3, 1.5, and 1.2 percent higher than that for Michigan 51B, Michigan 36B, Ohio M15, and Michigan 250 respectively. Michigan 250 has been 1.1

percent higher than Michigan 11A and 2.0 percent higher than Michigan 51B in shelling percentage.

SPRING COLD TOLERANCE

The ability to germinate and grow under cold, wet soil conditions is a desirable characteristic for hybrid seed corn. Cold, wet soil is conducive to seed rotting, and poor stands of corn may result. In laboratory cold germination tests, Michigan 350 and 250 have had good ratings for this characteristic when compared with a large number of corn hybrids. Careful processing and handling of the seed are necessary to preserve the inherent ability for good cold test germination. Both hybrids, particularly Michigan 350, have the ability to germinate quickly and make a rapid early growth, permitting a better and quicker job of cultivation.

APPEARANCE

The plants and ears of Michigan 350 and 250 are very attractive. The plants have a healthy dark green color when grown under optimum field conditions. Michigan 350 has a darker shade of green than Michigan 250.

The plant and ear heights of Michigan 350 are generally greater than those of Michigan 51B and about equal to those of Michigan 36B and Ohio M15. Heights of plants and ears of Michigan 250 are usually greater than those of Michigan 11A and Michigan 51B, but not quite so great as Michigan 350.

Ear shanks of the two new hybrids are short and the ears are held close to the stalk almost until maturity when they droop over and hang down. Short shanks may give the false impression that the yield will not be so good as that from a hybrid which has a long shank and which seems to have a longer ear. Loss of corn due to ears dropping onto the ground and losses due to ears being knocked from the stalk during harvest are generally less for hybrids with a short shank.

Ears of Michigan 350 and 250 are medium sized, with deep yellow grain borne on a small cob. The small cob and open husk facilitates drying in the field. False impressions may arise with respect to ear size. Yield and maturity of corn cannot be accurately determined by "looking" at the corn. Yield estimates based on size of ear are particularly misleading since the large-sized ears may be high in moisture, low in shelling percentage, or may be a result of thin stands which are not giving the maximum potential yield of corn per acre.

DEVELOPMENT OF MICHIGAN 350 AND MICHIGAN 250

The pedigrees of these new hybrids are as follows: Michigan 350 (W23 x MS24) x (W10 x MS206) and Michigan 250 (Oh51 x R53) x (W10 x MS206). Two of the six inbred lines involved in the foregoing pedigrees are new inbreds developed at the Michigan Agricultural Experiment Station. These two inbred lines, MS24 and MS206, have not been used previously in any released double-cross hybrid. W23 and W10 were developed at the Wisconsin Agricultural Experiment Station; Oh51 was developed at the Ohio Agricultural Experiment Station; and R53 was developed at the Illinois Agricultural Experiment Station. Without the cooperation and free exchange of breeding material among agricultural experiment stations, the breeding and development of improved corn hybrids would be slower and less effective.

MS24 was developed by inbreeding and selection in a cross of the Golden Glow open-pollinated variety with Maize Amargo made in 1926. Maize Amargo is a South American corn variety with some tolerance to the European corn borer. The material was inbred for five generations and crossed with the Duncan open-pollinated variety in 1932. This cross of (Golden Glow x Maize Amargo) x Duncan was inbred two generations and crossed again to the Golden Glow variety in 1935. Inbreeding and selection have continued since then, with the origin of MS24 now designated as [(Golden Glow x Maize Amargo) S_5 x Duncan] S_2 x Golden Glow.

MS206 was developed from the cross Golden Glow x Maize Amargo made in 1926, selfed five generations, crossed to the Duncan open-pollinated variety in 1932, inbred two generations, and crossed again to the Duncan variety in 1935 with continuous inbreeding and selection thereafter. The origin of MS206 is now designated [(Golden Glow x Maize Amargo) S_5 x Duncan] S_2 x Duncan.

The two inbreds, although remotely related in origin, are distinctly different in their characteristics and appearance. MS24 is a very attractive early maturing line with dark green leaves. Seed production is good, and it is easily maintained in the foundation seed program. MS206 is an extremely early maturing line that is relatively weak in vigor. Seed production is low, and it is difficult to maintain. Both inbreds mature quickly and dry at a rapid rate in the field after reaching maturity.

Several years of yield testing as top-cross hybrids were required to select for and establish the ability of these lines to contribute yield,

earliness, rapid maturity and drying, lodging resistance, and desirable appearance in crosses. In 1945, single-cross seed was produced in all 36 possible combinations among MS24, MS206, and six other inbred lines selected for their special characteristics. The single-cross hybrids were grown and evaluated in 1946. On the basis of performance records as single-cross hybrids and predicted performance as double-crosses, the double-cross seed for a number of combinations was produced in 1947. The double-cross hybrids were tested in 1948, 1949, 1950, and 1951 in over-state trials at a number of locations.

In order to be eligible for release by the Experiment Station and for seed certification by the Michigan Crop Improvement Association, a new corn hybrid must have been tested at least 3 years in over-state trials and it must demonstrate significant superiority over present certified hybrids of comparable maturity. The new hybrid need not necessarily be significantly higher yielding but may be superior in some other important agronomic characteristic.

When a new corn hybrid is developed as a result of corn breeding research at the Michigan Agricultural Experiment Station it is released for seed production in the following manner. Seed of each of the four inbred lines which are the parents of the new hybrid are released by the Experiment Station to the Michigan Foundation Seed Association, Inc. This organization has the responsibility of maintaining the genetic purity of the inbred lines and producing the foundation seed of the two single-cross hybrids used to make the double-cross seed. Seed of the inbred lines and single-cross hybrids is produced by the Foundation Seed Association under inspection by the Michigan Crop Improvement Association.

Single-cross seed of the two parents to be used for producing the double-cross seed is sold by the Foundation Seed Association to producers of Michigan certified hybrid seed corn, who are members of the Michigan Crop Improvement Association. Any one interested in certified seed production can become a member of the Crop Improvement Association and, thus, become a member of the Foundation Seed Association. He then becomes eligible to purchase foundation single-cross hybrid seed provided he agrees to use the seed to produce certified seed. The certified seed grower produces the double-cross hybrid seed under the seed certification program of the Crop Improvement Association. Double-cross hybrid seed corn that passes certification standards is distributed by the seed producer to Michigan farmers through commercial seed concerns.

CONTINUED BREEDING FOR CORN IMPROVEMENT

The "perfect" corn hybrid for all conditions has not yet been developed. Considering the extreme variation in soil and climatic conditions for corn production in Michigan, it is unlikely that any one "perfect" hybrid will be developed to answer the needs for all conditions.

Several hundred new experimental hybrids are tested every year by the Experiment Station with the objective of improving the yield, maturity, disease resistance, insect resistance, feeding quality, and other agronomic characteristics of corn hybrids. With reasonable success, it is likely that improved hybrids will continue to become available to the farmers of Michigan.

A number of generally adapted hybrids that differ in their individual characteristics is desirable for its stabilizing effect on corn production over a period of time. Stability of crop production is important both from the viewpoint of the individual farmer and the national economy. Specific weather and soil conditions, or a sudden large-scale outbreak of a disease or injurious insect could conceivably cause a serious or even disastrous reduction in the total corn crop if only a few hybrids were being grown and they were susceptible to the particular unfavorable environment. With an array of different hybrids, some being tolerant or resistant to specific unfavorable conditions that may arise, the drop in production in an adverse year is likely to be less.

To provide some degree of stability of corn production on the individual farm as a form of "crop insurance," two or three hybrids that differ slightly in maturity and other characteristics should be grown. If one hybrid runs into unfavorable weather at a critical stage in its development, the other hybrid may be less affected and come through with a good crop.

New hybrids are continually being developed, and they are worthy of a trial when they have been adequately tested. Even though a farmer has been growing a particular hybrid that has given satisfactory results, he may be able to improve his corn crop by trying one or more of the new hybrids that have been adequately tested in overstate trials. He may wish to try a new hybrid on a small scale in a strip in the same field with his present hybrid for a year or two to determine its adaptation to his local conditions.

SOME FACTORS THAT AFFECT PROTEIN CONTENT OF CORN[1]

By ALLAN J. NORDEN,[2] E. C. ROSSMAN, and E. J. BENNE
DEPARTMENTS OF FARM CROPS AND AGRICULTURAL CHEMISTRY

APPROXIMATELY 80 percent of the corn produced in the United States is fed to livestock. Most of the remainder is utilized for industrial purposes. The value of corn, either as feed or for industry, depends on its chemical composition.

Information on the effects of environmental, physiological, and genetic factors on chemical composition of corn is important to livestock feeders, feed manufacturers, industrial processors of corn, and others interested in the utilization of the crop. According to an estimate, if the feed corn of the state of Illinois declined only one-half of 1 percent in protein, it would cost the feeders of that state $8,710,000 annually for an equivalent amount of soybean protein as a replacement (3).

The purpose of this study was to determine the relation between and the effects of location, season, stage of maturity, and variety on the protein content of corn in Michigan. The four factors were combined in one experiment to permit an evaluation of their relative importance and to obtain information on the interaction of these factors. The various factors that affect growth of a crop do not operate independently, and there is often a high degree of interdependence or interaction among them.

REVIEW OF LITERATURE

The statement is frequently made that the development of high-yielding hybrids has resulted in lowering the protein percentage from

[1]A grant from the Michigan Certified Hybrid Seed Corn Producers' Association helped to finance this study.
[2]Formerly graduate assistant in Farm Crops.

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an average of 9.5 percent for open-pollinated varieties to about 8.5 percent for hybrids (12, 16). However, the total yield of protein per acre is much in favor of hybrid corn because of its higher yielding ability. Hunter (12) estimated that it would require 2,268,000 tons of soybean meal costing $181,000,000 to supplement the average decrease of 1 percent in protein content of corn in the United States.

Several comparisons show that there are hybrids being grown by farmers that have higher protein contents than the open-pollinated varieties in the same test. Twenty-one Wisconsin hybrids, ranging from 8.60 to 10.72 percent protein, averaged 9.53 percent, as compared with 9.44 percent for the Golden Glow open-pollinated variety (17). In Michigan, Schaible (20) found that 14 hybrids in Wexford County ranged from 7.75 to 10.08 percent and averaged 8.87 percent while three open-pollinated varieties ranged from 8.93 to 9.76. In Saginaw County, 22 hybrids ranged from 8.54 to 10.10 percent with an average of 9.10 percent which was slightly higher than the average of 8.91 percent for two open-pollinated varieties with 8.27 and 9.56 percent respectively.

Earley and DeTurk (3) concluded that the decline in protein reported by the feed industry is not due to inherently low-protein hybrids. They reported that the two most important factors controlling protein content of corn are rate of planting and nitrogen fertility of the soil. The decrease in corn protein observed by the feed industry was believed to be caused by both a decreased soil nitrogen at regular rates of planting and by an increased rate of planting on soils relatively low in nitrogen. These authors believed that protein content of corn has not declined universally throughout the Corn Belt but only on those farms where either the soil nitrogen is depleted or the rate of planting has been increased out of line with the nitrogen fertility of the soil.

Variations in protein content of corn caused by seasons, locations, and soil type have been found by several investigators (2, 13, 20, 22, 24). Leonard and Clark (13) found that thinner rates of planting resulted in the highest protein percentage while method of planting (hills or rows) had no effect on protein. Fraps (6) reported that protein in corn decreased as the rainfall increased. Webster *et al.* (22) concluded that varietal differences due to seasons and locations in Oklahoma made it undesirable to use average figures for corn protein when computing feed mixes.

Total protein content has been found to decrease as the corn grain matures (2, 5, 20). Zeleny (24) reported that the zein fraction of corn protein increased as corn matured, while water-soluble non-protein nitrogen decreased at about the same rate. Globulin and glutelin fractions of corn protein were synthesized at uniform rates as the grain matured.

Earley and DeTurk (3) investigated the effects of rate of planting and soil nitrogen on protein content of corn grain. They concluded that when yield of corn was increased through increased rates of planting, protein percentage decreased as the yield increased. but the percentage decrease usually diminished for each increment of nitrogen added to the soil. When the yield of corn was increased through nitrogen fertilization at a given rate of planting, protein content usually increased as yield increased. They suggested that the first increments of nitrogen added to the soil tend to increase grain yield more than grain protein while further increments tend to increase portein content of the grain as the yield levels off.

Evidence that the protein content of corn can be modified by plant breeding and selection is well established. The Illinois selection experiments, started in 1896 with the Burr White open-pollinated variety, resulted in raising protein content from 10.9 to 19.2 percent after 48 generations of selection under open pollination (23). By selecting for low protein, the amount was reduced to 5.1 percent. East and Jones (4) isolated high-protein lines by inbreeding. They made as much progress in six generations of inbreeding as the Illinois workers made in 20 generations of ear-to-row breeding under open pollination. Hayes and Garber (10) developed inbred lines with 15-percent protein from the open-pollinated Minnesota No. 13 variety. The high-protein lines were used to develop a synthetic variety which yielded somewhat better than Minnesota No. 13 and had slightly over 2 percent more protein.

A survey of 375 inbred lines representing most of the available lines in 1946 showed that protein contents ranged from 10 to 17 percent (23). Crossing widely used inbred lines with the Illinois high-protein strain and subsequent backcrossing to both parents were effective in increasing the protein content from a range of 11 to 14 percent in the original standard lines to a high of 22 percent in the recovered lines. Preliminary tests in 1948 indicated that certain of these lines yielded as well in hybrids as the original standard lines and the hybrids were considerably higher in protein than ordinary hybrids.

An inverse relationship between protein content and yield of corn has been reported by several investigators (4, 7, 10). Protein percentage decreased as the yield of grain increased. Other workers have found that this relationship does not always occur. Correlation, 0.115, of protein with yield for 81 hybrids in Illinois was not significant (23). Earley and DeTurk (3) found that where soil nitrogen was adequate, high yields were accompanied by increased protein content. Schaible (20) reported that there was no consistent relationship between the protein percentage and the yield of corn.

Osborne and Mendel (18) showed that the zein fraction of corn protein is deficient in tryptophan and lysine and poor in several other essential amino acids. Zein was found to constitute the major protein of the endosperm and was absent from the corn germ. Animals rapidly lost weight on a diet containing zein as the only source of protein, demonstrating that zein was nutritionally incomplete. Corn germ protein has been shown to approximate animal protein in nutritional quality (15).

In discussing the nutritive value of corn proteins, Hamilton (8) pointed out three possible ways in which the protein content of corn may increase, and he predicted the probable nutritive value of the new corn protein. "1) If the protein content is increased by increasing all of the proteins in corn in the same ratios as they now exist, corn as a carrier of protein would have an increased protein value—less concentrates would be needed to balance rations for livestock. The nutritive value of the proteins themselves would not be changed. In order to accomplish this, it is reasonable to suppose that all parts, particularly the germs and the horny endosperm, would be increased in size in the same proportions. 2) If the protein content is increased by increasing primarily the concentration of germ proteins, then the new high protein corn might be expected to have a higher nutritive value than has today's corn. 3) If the increase in protein content is brought about by increasing the amount of horny endosperm the nutritive value of the new high protein corn might be lower since the horny endosperm contains much of the gluten and zein."

There is evidence that increases in total protein of corn brought about either by fertilization or breeding may be due to an increase in the zein fraction of the protein (9, 21). Corn with a higher protein content brought about by increasing the zein fraction may actually be lower in nutritive value for non-ruminant animals such as man, swine, and fowl (8). For animals with a ruminant type of digestion,

cattle and sheep, any increase in protein content would actually save protein concentrates since the biological value of proteins for these animals is measured more by total protein than by the amino acid distribution.

Earley and DeTurk (3) stated that 12-percent protein corn would be worth about $9,500,000 more annually to Illinois feeders of beef cattle, dairy cattle, and sheep than 10-percent protein corn.

MATERIALS AND METHODS

Shelled grain samples from eight double-cross hybrids grown in two seasons (1948 and 1949), at three locations (Monroe, Ingham, and Saginaw Counties) and harvested at three stages of maturity were analyzed for protein content. The eight hybrids were included along with other hybrids in the Michigan Hybrid Corn Trials conducted at the three locations in 1948 and 1949. They were chosen for this study because they were the only hybrids common to all six trials.

TABLE 1—Agronomic information for the six field trials

County and year	Soil type	Previous crop	Fertilizer	Row spacing	Date planted	Dates harvested
Saginaw, 1948	Brookston clay loam	Alfalfa-bromegrass sod	None	36"x42"	May 18	Sept. 10 Sept. 27 Oct. 21
Saginaw, 1949	Brookston clay loam	Alfalfa-bromegrass sod	None	36"x42"	May 10	Aug. 30 Sept. 17 Oct. 4
Ingham, 1948	Conover clay loam	Alfalfa	200 lb. 4-16-8 per acre	42"x42"	May 26	Sept. 13 Sept. 28 Oct. 19
Ingham, 1949	Conover clay loam	Soybeans and rye green manure	200 lb. 4-16-8 per acre	42"x42"	May 12	Sept. 1 Sept. 19 Oct. 7
Monroe, 1948	Brookston clay loam	Alfalfa-bromegrass sod	None	42"x42"	May 27	Sept. 16 Sept. 30 Oct. 26
Monroe, 1949	Brookston clay loam	Wheat seeded to sweet clover	250 lb. 0-14-7 per acre and 10 loads manure per acre	40"x40"	May 31	Sept. 20 Oct. 8 Oct. 25

Six randomized replications of each hybrid were planted in the field at each location. The corn was grown in hills with generally uniform stands of three plants per hill. For the purposes of this study, two replications were sampled for ear moisture content at each of the three dates of harvest in 1948, and four replications were sampled at each date in 1949. Yield determinations were made on all six replications at the third date of harvest. Samples from two replications at each date of harvest in both seasons were analyzed for protein content. Agronomic information for the six trials is presented in Table 1.

Total protein was determined by the Kjeldahl-Gunning-Arnold method (14). Average moisture content of the grain at the time of analysis was 5.06 percent. One analysis was made for each sample. Duplicate analyses made on a portion of the samples showed good agreement among duplicates. Leonard and Clark (13) found that duplicate analyses for portein did not increase the precision of their experiment. A single sample per plot was sufficiently accurate when the error of duplicate analyses was compared with the experimental error.

RESULTS AND DISCUSSION

Average protein percentages for the eight hybrids harvested at three stages of maturity at three locations in Michigan in 1948 and 1949 are presented in Table 2 and the analysis of variance in Table 3.

Protein content of corn ranged from 7.44 to 12.88 percent during the two years of this experiment. The large variation in protein content, 5.44 percent, is of considerable interest. It is apparent that the protein content of corn grain is the result of complex interactions of environmental, genetic, and physiological factors. Other factors not tested in this study undoubtedly have an effect.

Estimates of variance components (Table 3) were calculated in an attempt to evaluate the relative importance of the factors studied and as an aid to the interpretation of the analysis of variance (1). In this technique, the effect of each factor is made up of contributions from season, location, variety, stage of maturity, and error.

PROTEIN CONTENT AFFECTED BY ENVIRONMENT

In this experiment, protein content of corn was affected more by environmental factors (soil and climate) than by genetic differences among the eight hybrids or by the stage of maturity at harvest. The greatest source of variation was introduced by seasonal variations of

TABLE 2—Average protein percentages for eight hybrids harvested at three stages of maturity, and three locations in 1948 and 1949

1948

	Saginaw County				Ingham County				Monroe County				Average of all locations			
	Date of harvest			Ave.	Date of harvest			Ave.	Date of harvest			Ave.	Harvest			Ave.
	9-10	9-27	10-21		9-13	9-28	10-19		9-16	9-30	10-26		1	2	3	
Pfister P.A.G. 61	11.18	10.94	9.81	10.64	11.58	10.97	10.34	10.97	10.38	10.04	10.47	10.29	11.05	10.65	10.21	10.63
Pioneer 349	11.00	9.78	9.38	10.06	11.18	10.00	9.88	10.35	10.50	10.22	9.96	10.23	10.89	10.00	9.74	10.21
Pioneer 352	10.84	9.41	8.83	9.70	11.38	10.44	9.90	10.58	9.28	9.12	9.40	9.27	10.50	9.66	9.38	9.85
DeKalb 404A	11.00	10.60	10.22	10.60	12.88	11.38	10.40	11.55	12.04	11.78	11.10	11.64	11.97	11.25	10.57	11.26
Kingscrost KO	11.19	10.66	9.90	10.58	10.84	10.07	10.32	10.41	10.44	10.10	10.47	10.34	10.83	10.28	10.23	10.44
Michigan 20D	10.66	10.34	9.78	10.26	11.44	10.60	10.56	10.87	10.82	10.10	11.03	10.65	10.97	10.35	10.46	10.59
Michigan 29D	11.19	10.75	9.68	10.54	12.19	10.26	10.84	11.10	12.44	10.94	10.56	11.31	11.94	10.65	10.36	10.98
Ohio M15	10.75	10.22	10.25	10.41	10.94	10.04	10.47	10.78	10.63	10.88	11.25	10.92	10.77	10.68	10.66	10.70
1948 Average	10.98	10.34	9.73	10.35	11.55	10.58	10.34	10.83	10.81	10.40	10.53	10.58	11.12	10.44	10.20	10.58

1949

	8-30	9-17	10-4	Ave.	9-1	9-19	10-7	Ave.	9-20	10-8	10-25	Ave.	1	2	3	Ave.
Pfister P.A.G. 61	10.78	10.41	10.75	10.65	8.03	7.97	8.22	8.07	8.84	9.68	9.47	9.33	9.22	9.35	9.48	9.35
Pioneer 349	10.06	9.97	10.38	10.14	8.63	7.75	7.60	7.99	8.22	9.32	9.00	8.84	8.97	9.01	8.99	8.99
Pioneer 352	11.25	10.28	9.88	10.47	7.94	8.04	7.69	7.89	8.75	8.00	8.91	8.89	9.31	9.10	8.82	9.08
DeKalb 404A	11.28	10.78	10.54	10.87	8.40	7.63	7.82	7.95	10.25	10.14	9.97	10.12	9.98	9.52	9.44	9.65
Kingscrost KO	11.22	10.19	10.00	10.47	7.94	7.44	7.82	7.73	10.16	10.00	10.28	10.15	9.77	9.21	9.37	9.45
Michigan 20D	11.03	10.26	10.75	10.68	8.75	7.60	8.69	8.34	10.47	10.54	10.12	10.38	10.08	9.46	9.86	9.80
Michigan 29D	11.10	11.50	11.19	11.26	8.22	8.00	7.81	8.01	10.32	10.53	10.44	10.43	9.88	10.01	9.81	9.90
Ohio M15	11.32	10.90	10.90	11.04	7.60	7.84	8.34	7.93	9.47	9.66	9.97	9.70	9.46	9.47	9.74	9.56
1949 Average	11.00	10.54	10.55	10.70	8.19	7.78	8.00	7.99	9.56	9.86	9.77	9.73	9.58	9.39	9.44	9.47
Two-year average	10.99	10.44	10.14	10.52	9.84	9.18	9.17	9.41	10.19	10.13	10.15	10.15	10.35	9.92	9.82	10.03

TABLE 3—Analyses of variance for protein and yield of grain per acre

Source of variation	Protein content			Yield of grain	
	Degrees of freedom	Mean square	Component of variance	Degrees of freedom	Mean square
Seasons	1	87.170	0.1514	1	10,109.2
Hybrids	7	4.631	0.0914	7	974.9
Maturities	2	7.660	0.0276		
Locations	2	31.020	−0.3417	2	3,959.95
Seasons x hybrids	7	0.691	0.0091	7	18.8
Seasons x maturities	2	3.625	0.0643		
Seasons x locations	2	62.045	1.2775	2	16,018.4
Hybrids x maturities	14	0.426	0.0078		
Hybrids x locations	14	1.005	0.0404	14	114.1
Maturities x locations	4	1.752	0.0255		
S x H x M	14	0.261	0.0132		
S x H x L	14	0.449	0.0445	14	264.3
S x M x L	4	0.458	0.0185		
H x M x L	28	0.253	0.0178		
S x H x M x L	28	0.182	−0.0305		
Error	144	0.243	0.2431	240	134.4

location effects as indicated by the large component of variance associated with the interaction seasons x locations. Average protein content by years for each location is shown in Table 4 to illustrate this interaction. The effect of seasons varied, depending on the location. Corn in the Saginaw County trial had a higher protein content in 1949 than in 1948 while the reverse was true for corn at the other two locations.

Detailed study of Tables 1 and 4 shows that the protein content was closely related to the previous cropping history of each field. In

TABLE 4—Average protein percentage and yield of corn in bushels per acre at three locations in 1948 and 1949

Location	1948		1949		Two-year average	
	Protein	Yield	Protein	Yield	Protein	Yield
Saginaw County	10.35	70.6	10.70	109.5	10.52	90.1
Ingham County	10.83	72.5	7.99	81.9	9.41	77.2
Monroe County	10.58	90.1	9.73	77.5	10.15	83.8
Average	10.58	77.8	9.47	89.6		

1948, all three trials followed alfalfa or alfalfa-bromegrass in the rotation, and the protein content was quite uniform among the three locations, with an average of 10.58 percent. The average protein content in 1949 was 9.47 percent and the seasonal difference, 1.11 percent, was highly significant. Corn followed alfalfa-bromegrass in 1949 only in the Saginaw County test, and the protein content remained at a relatively high level of 10.70 percent. Highly significant decreases in protein content occurred in the Ingham and Monroe County tests where the 1949 crop did not follow alfalfa or alfalfa-bromegrass in the rotation. The decreases were 2.84 and 0.85 percent respectively. A marked nitrogen deficiency, as evidenced by leaf symptoms, developed after pollination in the Ingham County trial in 1949. This deficiency of nitrogen was probably responsible for a part of the large decrease in protein content at this location. In spite of the apparent nitrogen deficiency, corn yields remained at a high level, indicating that soil nitrogen may have been adequate for high grain yield but inadequate for high protein content. In both years, Ingham and Saginaw County tests were conducted on the same farms with the same soil types. Monroe County trials were conducted on Brookston soil in both years but on two different farms in the same neighborhood.

Effects of weather conditions associated with season and location were minor as compared with the effects due to crop rotation. The seasonal difference, 1.11 percent, was largely a result of a lack of legume sod crops in the rotations for the 1949 crop. Seasonal differences in weather conditions were responsible for some variation in protein content. The best measure of this effect was the difference between the two years in Saginaw County. The difference, 0.35 percent, was highly significant but of relatively low magnitude. Seasonal variation in protein content for the other two locations reflects differences due to previous cropping history more than variation due to climatic factors. Weather conditions were favorable for good growth and production of grain at all locations in both years as indicated by high yields.

For the entire experiment, variations in protein content due to the peculiarities of environment, principally soil type and climatic conditions, associated with a particular location were negligible; location differences were largely a result of seasonal differences in crop rotation. The best measure of location effects was found in 1948 when corn followed alfalfa or alfalfa-bromegrass at all locations. The differences among the three locations (0.23, 0.25 and 0.48 percent) were relatively

small although significant. In 1949 when crop rotations differed, the variation in protein content among the three locations was considerable.

While the foregoing presentation has stressed the importance of alfalfa in the rotation in maintaining relatively high protein content in corn, the supply of soil nitrogen was probably the critical factor. When sufficient nitrogen is added as fertilizer in the absence of a legume sod crop, the protein content of corn could likely be maintained at an equally high level.

PROTEIN CONTENT AFFECTED BY HYBRID VARIETY

The average protein content for the eight hybrids during the 2-year period ranged from 9.46 to 10.46 percent. The component of variance for hybrids was third in relative size, indicating that genetic differences among the varieties were responsible for some of the variation in protein content. Larger varietal differences than these probably occur among hybrids in general since the hybrids in this study were not selected specifically because of their protein content.

DeKalb 404A (10.46 percent) and Michigan 29D (10.44 percent) were the highest in average protein content over the 2-year period; Michigan 20D (10.20 percent), Pfister P.A.G. 61 (9.99 percent), Kingscrost KO (9.95 percent), and Ohio M15 (10.13 percent) were intermediate; Pioneer 349 (9.60 percent) and Pioneer 352 (9.46 percent) were lowest. The average protein content in 1948 ranged from 11.26 for DeKalb 404A to a low of 9.85 percent for Pioneer 352. In 1949, it ranged from an average of 9.90 for Michigan 29D to 8.99 percent for Pioneer 349. The protein content was higher in 1948 than in 1949 for all hybrids. All hybrids, except one, averaged above 10 percent in 1948, while all hybrids were below 10 percent in 1949. The correlation of average protein content in 1948 with 1949 for the eight hybrids was 0.779 which was significant, indicating that the hybrids that were high in 1948 were also high in 1949. The interaction of seasons x hybrids was not significant. However, the protein content of some hybrids decreased more than others from 1948 to 1949. The average decrease for DeKalb 404A was 1.61 percent and that for Pioneer 352 was 0.77 percent.

Significant correlation coefficients showed that hybrids high in protein at one location tended to be high at other locations. There were differences among hybrids in the amount of increase or decrease from location to location. For example, Kingscrost KO averaged 1.46

percent lower in protein content in Ingham County trials than in Saginaw County trials, while Pioneer 352 averaged 0.85 percent less.

Correlations of date of harvest with protein content indicated that the hybrids that were high in protein content at the first harvest were also high at the second and third harvests. The interaction of hybrids with stage of maturity was not significant, indicating that the hybrids tended to react alike at the three dates of harvest.

All interactions involving hybrids were generally small, compared with interactions not involving hybrids. This indicates that the response of hybrids was more consistent than the response to the other factors. Differences in protein content among hybrids were largely due to genetic factors, and these were not greatly affected by environment and stage of maturity.

In a corn-breeding program designed to develop high-protein hybrids, the inbred lines undergoing selection for protein should be grown on soils high in nitrogen to permit full expression of genes for high protein. Experimental double-cross hybrids from the program should be tested under a range of soil nitrogen supplies to determine if the genetic constitution for high protein will hold up under all or most conditions.

PROTEIN CONTENT AFFECTED BY STAGE OF MATURITY

Protein content decreased as the grain matured. The average was 10.35, 9.92, and 9.82 percent for the three dates of harvest when the average moisture content of the ear was 51.9, 40.7, and 31.9 percent respectively. All protein percentages are reported on an equal basis of dry grain containing about 5-percent moisture at the time of analysis. The total effect of stage of maturity was smaller than the effect of the other factors as indicated by components of variance.

In 1948, the average protein content was 11.12, 10.44, and 10.20 percent when the average ear moisture content was 53.6, 42.1, and 34.4 percent respectively. Significant changes in protein content occurred among the three stages of maturity. The effect of date of harvest was smaller in 1949 when the grain was more nearly mature at the first two dates. Average protein content in 1949 was 9.58, 9.39, and 9.44 percent when the average moisture content was 51.0, 40.0, and 30.7 percent respectively. The decrease, 0.19 percent, from the first to the second harvest in 1949 was significant, but there was no significant change from the second to the third harvest.

Corn is generally considered to be mature when the ear moisture content has decreased to about 40 percent. In this experiment there was no significant change in protein percentage after the corn had reached 40-percent moisture.

There was no relationship between the relative maturity of a hybrid and the protein content of the grain. The correlation was 0.185 which was not significant. Early maturing hybrids did not necessarily have more or less protein than later maturing hybrids; however the range in maturity, approximately one week, was small.

EFFECT OF YIELD ON PROTEIN CONTENT

Average yields for the eight hybrids at the three locations in 1948 and 1949 are given in Table 5 and the analysis of variance in Table 3.

TABLE 5—Average yields in bushels per acre for eight hybrids at three locations in 1948 and 1949

Hybrid	1948				1949				2-year average
	Saginaw	Ingham	Monroe	Ave.	Saginaw	Ingham	Monroe	Ave.	
Pfister P.A.G. 61	72.0	79.6	93.4	81.7	109.1	88.8	79.4	92.4	87.1
Pioneer 349	76.7	75.7	97.7	83.4	113.7	94.7	79.5	96.0	89.7
Pioneer 352	76.7	83.7	100.3	86.9	117.0	81.4	85.7	94.7	90.8
DeKalb 404A	63.3	57.0	91.4	70.6	114.0	79.5	69.3	87.6	79.1
Kingscrost KO	70.4	68.8	81.5	73.6	111.2	83.9	80.3	91.8	82.7
Michigan 20D	66.2	73.0	87.6	75.6	113.2	80.8	76.9	90.3	83.0
Michigan 29D	74.9	69.0	89.6	77.8	106.5	73.1	76.6	85.4	81.6
Ohio M15	64.8	73.4	79.6	72.6	91.0	73.0	72.0	78.6	75.6
Average	70.6	72.5	90.1	77.8	109.5	81.9	77.5	89.6	.....

Yields of corn were significantly affected by season, location, and hybrids. Hybrids tended to respond alike to location and season as evidenced by the non-significant interactions. Interaction of location with seasons was very large. Location differences for yield were not related to the presence or absence of alfalfa or alfalfa-bromegrass in the rotation as was the case for protein content.

It is frequently stated that protein percentages tend to decline as corn yields increase. This is another case where it is hard to get clear-cut evidence because of various interrelationships.

In the Saginaw and Monroe County tests, the higher average yields were accompanied by higher protein percentages (Table 4). Corn followed alfalfa-bromegrass sods both years in Saginaw County. In Monroe County, corn followed an alfalfa-bromegrass sod in 1948 when yield and protein content were high, and followed a wheat crop seeded to sweet clover in 1949 when yield and protein content were lower. When corn followed alfalfa or alfalfa-bromegrass in the rotation, protein content tended to be high. Higher yields in 1949 in Ingham County were associated with a lower protein content when corn followed a soybean-rye green manure crop. A marked deficiency of nitrogen developed at Ingham County in 1949 and probably contributed to the lower protein contents. While the data in this study are not critical, they suggest that the corn plant utilizes nitrogen first for growth processes related to maximum yield under the prevailing environment and excess nitrogen not needed for these processes is devoted to an increase in protein.

Considering the six trials, the correlations of yield with protein content for the eight hybrids were: –0.896** (Saginaw 1948), –0.557 (Saginaw 1949), –0.491 (Ingham 1948), –0.268 (Ingham 1949), –0.763* (Monroe 1948), and –0.570 (Monroe 1949). Only two of the six correlations were significant, those for Saginaw and Monroe Counties in 1948. The trend was toward lower protein content when yield was higher, but the relationship was generally small and not significant.

Correlation of yields with protein percentages at the third date of harvest for the entire experiment was 0.147, which was not significant. There was no relationship between yield and protein content when one considered the whole population regardless of season, location, and hybrid.

Correlation coefficients, 0.042, 0.124, and 0.166 for the three dates of harvest, showed no relationship between kernel weight and protein content.

SUMMARY

Shelled grain samples of eight corn hybrids harvested at three stages of maturity from three different locations in 1948 and 1949 were analyzed for protein content.

Protein content of corn varied from 7.44 to 12.88 percent during the 2 years of this experiment, depending upon the particular season, location, stage of maturity and hybrid. It is apparent that protein con-

*Significant.
**Highly significant.

tent is the result of complex interactions of environmental, genetic, and physiological factors, and it is difficult to predict the protein content of corn without information on all of the variables.

Environmental factors (soil and climate) had a relatively greater effect on protein content than genetic factors. Of these, the supply of soil nitrogen appeared to be the critical factor affecting protein percentage. When corn followed alfalfa in the rotation, protein content was higher than when corn followed other crops. Under some conditions, the soil nitrogen supply was adequate for good yields but inadequate for maximum protein content. Apparently the corn plant uses the available nitrogen first for growth processes related to maximum yield under the prevailing environment, and excess nitrogen not needed for those processes is devoted to an increase in protein.

In this experiment, seasonal differences in weather conditions had a comparatively smaller effect on protein percentage than the previous crop. Weather conditions in both years were favorable for good corn production.

Genetic differences among hybrids were relatively more important in determining protein content than stage of maturity or locational differences in weather conditions and soil type. The average protein for the eight hybrids ranged from 9.46 to 10.46 percent. Larger differences than these probably exist among hybrids in general, since the hybrids in this experiment were not selected for their protein contents.

DeKalb 404A and Michigan 29D were highest in average content over the two year period: Michigan 20D, Pfister P.A.G. 61, Kingscrost KO, and Ohio M15 were intermediate; Pioneer 349 and Pioneer 352 were lowest.

Hybrids tended to respond alike in both seasons, at all locations, and at all stages of maturity. There were significant differences among the hybrids in the amount of increase or decrease in protein from one set of conditions to another, but the hybrids that were high in protein content tended to be relatively high under all conditions. Earlier maturing hybrids did not necessarily have more or less protein than the later maturing hybrids in this study.

Protein content decreased as the grain matured. Average protein content was 10.35, 9.92, and 9.82 percent when the average moisture content of the ear was 51.9, 40.7, and 31.9 respectively. There was no significant change in protein content after the moisture reached 40 percent.

Considering the entire experiment regardless of season, location and hybrid, there was no relationship between yield of corn and protein content. The high-yielding hybrids tended to be lower in protein content, but the tendency was significant in only two of the six trials.

There was no association between kernel weight and protein percentage.

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NITROGEN TOP DRESSINGS FOR WHEAT ON HEAVY SOILS

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IN 1936 Cook and Millar[1] concluded that it was not practical to make specific recommendations in regard to the spring application of nitrogen on wheat growing on heavy soil. At that time it was difficult to predict when positive responses might be expected. Since then, however, two diagnostic techniques—the identification of plant nutrient deficiency symptoms and plant tissue testing—have been improved to such an extent that their use aids considerably in predicting when and where extra nitrogen might result in higher yields. Furthermore, many changes have occurred in soil management practices and crop harvesting techniques, and there is definite evidence to show that the need for nitrogen top dressings on heavy soils has increased greatly over the past few years.

The object of this report is to present the results of studies made to determine the response of winter wheat, growing on heavy soils, to spring applications of nitrogen. Observations are also reported in regard to the use of plant tissue testing and nitrogen deficiency symptoms as aids in determining the time and rate of applying nitrogen.

PROCEDURE

In order to determine which fields of wheat might respond to nitrogen top dressings, definite amounts of ammonium sulfate, along with instructions for application, were given to farmer cooperators. Early spring top dressings at the rate of 75 pounds per acre were made at 83 locations in 8 southeastern Michigan counties. At harvest time county agricultural agents and vocational agriculture instructors

[1]Cook, R. L. and Millar, C. E. The Effect of Spring Applications of Soluble Nitrogen Fertilizer on the Yields of Wheat on Heavy Soils. Mich. Agr. Exp. Sta. Quart. Bul., *18* (3) : 182-192. 1936.

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assisted the farmers in harvesting samples from top-dressed and from "check" areas.

At other locations the nitrogen was broadcast by hand (by the writers) in fields on private farms which showed a) nitrogen deficiency symptoms, b) low or blank plant tissue tests, or c) a cropping history which indicated that they would respond to nitrogen. These were randomized plots replicated 4 to 6 times.

All samples were harvested by hand and transported to the College farm where they were threshed.

RESULTS

A summary of the results from 83 locations where farmers applied nitrogen shows that at 34, or 40 percent, of the locations the crop responded profitably to the nitrogen top dressing. Those fields produced more than 2.5 extra bushels of wheat per acre, which represents the approximate cost of the nitrogen plus the cost of application. The average increase in yield at the 34 locations was 5.8 bushels per acre. The greatest increase was 13.7 bushels.

In 1951 parts of 12 fields of wheat in five counties were top-dressed with 20 pounds of nitrogen per acre (100 pounds sulfate of ammonia). Each of these fields was selected because the cropping history indicated that a nitrogen top dressing should increase the yield. No manure

TABLE 1—The effect of 100 pounds of ammonium sulfate top-dressed in the early spring on wheat yield

Field number	County	Crop* sequence	Not topdressed	100 Pounds $(NH_4)_2SO_4$	Increase
			(Bu./acre)	(Bu./acre)	(Bu./acre)
1	Livingston	C,O,W,W	17.9	24.6	6.7
2	Livingston	W,W,O,W,W	16.3	22.5	6.2
3	Livingston	W,W,W	14.8	18.1	3.3
4	Livingston	O,W,W	36.8	44.3	7.5
5	Eaton	C,C,O,W,W	35.2	42.8	7.6
6	Barry	C,O,W	35.9	37.3	1.4
7	Ionia	O,W	24.8	37.3	12.5
8	Ionia	W,W	35.9	44.2	8.3
9	Huron	W,Be,W	51.1	53.8	2.7
10	Huron	Be,W,W	38.6	46.9	8.3
11	Huron	S.B,Ba,W	40.0	46.9	6.9
12	Huron	S.B,Ba,W,W	37.3	44.2	6.9

*C-Corn, O-Oats, W-Wheat, Be-Beans, Ba-Barley, S.B.-Sugar beets.

had been applied to any of the fields. The cropping history and yields are shown in Table 1, and the data show that under such crop sequences, nitrogen top dressings increased average wheat yields by 6.5 bushels per acre.

The results of tissue tests made at the time the wheat was top-dressed are presented in Table 2. The data show the value of tissue testing because yield increases resulted in every field where low nitrate tests were obtained. The wheat on the Jens and Freeman farms showed severe nitrogen deficiency symptoms at the time the wheat was top-dressed, and plant tissue tests confirmed the observations. At the Stillman farm (No. 2) the wheat followed beans and, at the time the top dressing was made, gave a high test for nitrate. Two weeks later, however, the nitrate test was low. This illustrates the point that tissue test results show the nitrate level in the plant at the time the test is made but that a single test does not show the nitrogen-supplying power of the soil. The rest of the fields did not show strong nitrogen-deficiency symptoms, and it was only through use of the plant tissue tests that it was possible to predict the response to nitrogen.

TABLE 2—Effect of topdressing wheat with nitrogen on yields and plant tissue tests for nitrogen

Farm	County	Nitrate tissue test*	Yield, bus./acre			Carrier	Rate
			Check	Nitrogen topdressed	Increase		
Jens.....	Lapeer...	B	18.9	32.9	14.0	NH_4NO_3	100
Aseltine.....	Ingham..	T	24.0	29.4	5.4	$(NH_4)_2SO_4$	100
Stillman No. 1.	Ingham..	B	21.0	24.3	3.3	$(NH_4)_2SO_4$	100
Stillman No. 2.	Ingham..	H	34.4	44.5	10.1	$(NH_4)_2SO_4$	50
Ferden—1949 .	Saginaw..	L	26.6	32.6	6.0	$(NH_4)_2SO_4$	100
Freeman.....	Saginaw..	B	28.0	39.2	11.2	NH_4NO_3	100

*B-Blank, T-Trace, L-Low, H-High.

The effect of different rates of nitrogen on wheat yields is shown in Table 3. In every instance 50 pounds of ammonium sulfate increased the wheat yield substantially and, with one exception, 100 pounds greatly increased the yield. On the Stillman farm the wheat followed beans which possibly supplied some available nitrogen. There the heavier application may have been too much for the balance with other nutrients. The plants lodged and became severely infested with

mildew. This undoubtedly accounts for the low yield with that treatment. Two hundred pounds of ammonium sulfate did not in any of the fields substantially increase the yields above those which resulted from the 100-pound rate.

TABLE 3—Effect of different rates of nitrogen top dressing on wheat yields

Farm	Nitrogen carrier	Fertilizer rate and wheat yield (bu./acre)					
		0	50	100	200	300	400
Aseltine	Ammonium sulfate	24.0	27.4	29.4	.....	.....	.....
Stillman	Ammonium sulfate	21.0	24.3	24.3	.....	.....	.....
Stillman	Ammonium sulfate	34.4	44.4	32.7*	.....	.....	.....
Ferden	Ammonium sulfate	26.6	.....	32.6	30.7	32.3	33.0
Freeman	Ammonium nitrate	28.0	.....	39.2	35.5	.....	.....
Sober	Ammonium sulfate	14.5	.....	23.5	24.2	.....	.....
Garvit	Ammonium sulfate	29.7	.....	42.9	45.6	.....	.....
Evans	Ammonium sulfate	35.3	.....	48.4	49.8	.....	.....

*Lodged and severely infested with mildew.

DISCUSSION

It is evident from the data presented, that a large number of wheat fields in Michigan are not producing maximum yields because of a lack of adequate amounts of available nitrogen. It is difficult to predict which fields might respond to nitrogen without the aid of plant nutrient deficiency symptoms and plant tissue tests because weather conditions influence top dressing results considerably. An extreme case illustrates this point.

In 1945 warm weather prevailed early in the spring. After the wheat had been growing vigorously for several weeks, winter-like weather returned and temperatures dropped low enough to freeze the soil on several occasions. By the end of April the wheat in many fields had turned so yellow that some farmers considered plowing their wheat under. The appearance of the wheat was typical of nitrogen starvation. This was verified by plant tissue tests. One field in Lapeer County showed nitrogen-starvation symptoms, and the test for soluble nitrogen was low despite the fact that alfalfa had preceded the wheat and 300 pounds of 3-12-12 had been applied with the wheat at planting time. Small plots were laid out in this field and some of the wheat was top-dressed with 100 pounds of ammonium nitrate per acre. The

check plots yielded 18.9 bushels per acre, and the nitrogen top-dressed wheat yielded 32.9 bushels. These results illustrate the value of being able to recognize plant nutrient deficiency symptoms and the value of plant tissue testing. Theoretically, this wheat should have had ample nitrogen from the plowed-down alfalfa. The unseasonably cold weather had reduced or stopped nitrification, and low wheat yields resulted where additional nitrogen was not applied.

Plant tissue testing is neither difficult nor expensive. The test indicates in a semi-quantitative way whether or not a plant is getting sufficient nutrients to satisfy its needs **at the time the test is made.** By testing frequently, it is possible to detect a nutrient deficiency previous to the development of visual symptoms.

Nitrogen deficiency symptoms displayed by wheat have been well defined by Cook and Millar.[2] Generally a retarded growth rate is accompanied by a light green color of the leaves. As the condition becomes more severe, the leaves develop a distinct yellow color. The yellowing occurs first on the basal leaves beginning at the tip. More intense nitrogen deficiency symptoms show that the yellowing progresses from the tip of the leaf up the midrib rather than along the edges. Cook and Millar suggest that when possible it is well to confirm the diagnosis by making plant tissue tests.

While no conclusive data are available in regard to the best time to apply nitrogen top dressings on wheat, it is believed that the earlier it is applied in the spring, the greater will be the response. Top dressings made as early as the first week in March have produced marked yield responses. On the other hand, adjacent top dressings made in May just prior to heading time produced equally large responses. From these results it would seem that there are two periods when wheat may be top-dressed most satisfactorily. The first is in the early spring while the soil is frozen. At that time tractor and fertilizer drills may be driven across fields without puddling the soil. However, wheat grown on rolling land probably should not be top-dressed at that time because of the danger of surface washing which may carry some of the nitrogen away. The other period, when wheat may be top-dressed without puddling the soil, if after the soil has drained and is relatively dry but before the wheat has made much growth.

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[2]Cook, R. L. and Millar, C. E. Plant Nutrient Deficiencies. Mich. Agr. Exp. Sta. Spec. Bul. 353. 1949.

SUMMARY

Nitrogen top dressings were made on wheat on heavy soils at 101 locations. The result of these experiments show that about 40 percent of the wheat fields yielded more when adequate amounts of nitrogen were available to the crop. Wheat grown in cash crop systems of farming responded greatly and consistently to nitrogen top dressings.

By means of deficiency symptoms and green tissue tests, it was found to be possible for one to predict with a fair degree of accuracy where he might expect profitable yield increases as a result of nitrogen top dressings.

The results showed 20 pounds of nitrogen per acre to be the most profitable rate of application.

THE EFFECT OF FERTILIZER ANALYSES ON YIELDS OF VARIETIES OF MALTING BARLEY[1]

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THERE is an increasing tendency for agronomists to recommend crop varieties according to soil fertility levels. Usually such recommendations are based upon agronomic characteristics, such as susceptibility to lodging, maturity date or other field characteristics. However, information is not usually available concerning variety yield responses to varying rates of fertilizer application or varying fertilizer analyses. Accordingly, in the spring of 1947, investigations were initiated to determine if the malting barley varieties commonly grown in Michigan and other midwest states respond alike to different fertilizer treatments. Response was based on grain yield.

LITERATURE REVIEW

As early as 1922 the Tennessee Agricultural Experiment Station recommended varieties of corn on the basis of soil fertility levels (9). Moores (9), Stringfield and Salter (14), Smith (13), and Arceneaux (1) have reported significant interactions of corn varieties and fertilizers. Carter and Hopper (2), Middleton and Farrior (8), Fisher and MacKenzie (3), and Hurst, *et al.* (5), working with soybean, peanut, potato, and sugar beet varieties, respectively, did not find differential yields of the varieties at varying fertility levels.

Lamb and Salter (6) and Worzella (15) have reported that certain wheat varieties responded differently to changes in fertility levels, while Reitz and Myers (11) concluded that wheat varieties of similar adaptation tend to respond in a similar manner to fertilization. Working with oat varieties, Lamb and Salter (7) were unable to find a

[1]These barley variety-fertilizer experiments were supported in part by a grant-in-aid from the Midwest Barley Improvement Association.

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differential yield response to fertility levels. Likewise, Gregory and Crowther (4) found no differential response of grain yield in barley varieties grown at different levels of nitrogen and phosphorus. The straw yields, however, did show a differential response to nitrogen fertilization.

MATERIALS AND METHODS

The experiments were conducted at four locations during the years 1947-50 in the "Thumb" area of Michigan upon soil which has been mapped as Brookston Clay loam. This soil type is well adapted to the production of malting barley. The field design used in each experiment was a split plot arrangement with four replications. The barley varieties grown in these experiments, all of which, except Moore, are acceptable to the malting trade were as follows:

1947—Bay, Wisconsin 38, O.A.C. 21,
1948—Bay, Wisconsin 38, O.A.C. 21, Montcalm, Kindred
1949—Bay, Wisconsin 38, O.A.C. 21, Montcalm, Moore
1950—Bay, Wisconsin 38, O.A.C. 21, Montcalm, Moore

The fertilizer treatments in 1947 were check (no treatment), 0-16-16, 4-16-8, and 4-16-16 analyses applied at the rate of 500 pounds per acre. In subsequent years the analysis 0-16-0 was added to those given above. Each variety received all of the treatments.

EXPERIMENTAL RESULTS

The grain yields of barley in 1947 are given in Table 1. The yields of the three barley varieties were approximately the same on the unfertilized plots, and on the 0-16-16 plots none of the varieties showed any marked increase in yield. When complete fertilizers were applied

TABLE 1—Grain yields in bushels per acre for three barley varieties grown with several fertilizer treatments in 1947

Variety	Fertilizer				
	No treatment	0-16-16	4-16-8	4-16-16	Mean
Bay	32.4	37.5	45.6	45.3	40.2
Wisconsin 38	34.3	38.9	50.2	48.6	43.1
O.A.C. 21	33.2	34.3	34.4	36.1	34.4
Mean	33.2	37.0	43.4	43.3	.....

the average yield of Bay and Wisconsin No. 38 varieties was increased 14.5 bushels per acre, while O.A.C. 21 still failed to show any yield response. Statistical analysis showed this differential response to be highly significant. The marked increase in the yield of Bay and Wisconsin No. 38 varieties when complete fertilizers were applied is probably due to the fact that the test area was worked when the soil was wet. Consequently, it was slightly compacted. Numerous observations have been made on other crops where response to nitrogen resulted when the soil had been compacted.

The grain yields of the five barley varieties grown in 1948 are presented in Table 2. The range in yield among varieties on the unfertilized plots was much greater than in 1947. Undoubtedly the

TABLE 2—Grain yields in bushels per acre of five barley varieties, grown with several different fertilizer treatments in 1948

Variety	Fertilizer					
	No treatment	0-16-0	0-16-16	4-16-9	4-16-16	Mean
Bay	42.8	44.4	46.9	49.4	47.7	46.2
Wisconsin 38	47.8	50.0	53.5	53.7	55.0	52.0
O.A.C. 21	29.2	27.9	29.3	36.2	31.0	30.7
Montcalm	49.4	50.0	51.9	57.8	58.0	53.4
Kindred	39.4	29.4	45.8	50.0	46.8	44.3
Mean	41.6	42.4	45.5	49.4	47.7	.....

explanation for this was twofold; first, the growing season of 1948 was very favorable for barley production and the varieties were better able to express their natural yielding ability, and second, the plots were located in a field which, according to soil test, was exceptionally high in fertility. In spite of the high natural fertility level of the soil, significant increases in barley grain yield resulted from the fertilizer application; especially from the complete fertilizers. However, a comparison of the yields from the 4-16-8 and 4-16-16 plots indicated that response to both was about the same. It is of interest that the differential yield response of O.A.C. 21, Bay and Wisconsin No. 38, which was present in 1947, was not evident in 1948.

In 1949 (Table 3) there were no significant differences among the yields of the five barley varieties. Fertilizer, regardless of the analysis, increased the average grain yield materially. The efficiency of phos-

TABLE 3—Grain yields in bushels per acre of five barley varieties, grown with different fertilizer treatments in 1949

Variety	Fertilizer					
	No treatment	0-16-0	0-16-16	4-16-8	4-16-16	Mean
Bay	38.7	44.4	42.8	50.2	46.1	44.4
Wisconsin 38	36.8	46.1	47.1	46.5	53.2	45.9
O.A.C. 21	34.7	44.8	42.7	47.6	46.8	43.3
Montcalm	40.8	49.0	47.2	52.6	53.8	48.7
Moore	34.0	43.5	50.2	45.2	40.1	42.6
Mean	37.0	45.6	46.0	48.4	48.0	.....

phorus in increasing yield was probably due to two factors: first, the test area was located on a plowed down alfalfa sod, and second, manure was applied to the area before planting. Alfalfa is notably a heavy phosphorus feeder, and manure is relatively low in phosphorus. Consequently, available phosphorus in the soil was low in comparison with the other nutrients, nitrogen and potash, and the result was a pronounced response to phosphorus. However, despite the previous soil treatment, cropping with alfalfa and manure applications, the highest yield with each variety, except Moore, was produced on the plots which received a complete fertilizer. There was a significant interaction of varieties and fertilizers in 1949 owing to Moore's responding differently than the other varieties. The yield of this variety was markedly increased by the incomplete fertilizers, 0-16-0 and 0-16-16, but the yield decreased when complete fertilizers, 4-16-8 and 4-16-16, were applied. This is somewhat contrary to other observations (12). Possibly in this trial, the reduced yield was caused by improper balance of the fertilizer constituents rather than by excess nitrogen.

The grain yields of the five barley varieties grown in 1950 are shown in Table 4. The average yield increase due to the incomplete fertilizers was 4.0 bushels per acre and to complete fertilizers 8.0 bushels per acre. This again shows the relative advantage of sowing a complete fertilizer with barley. Even though the fertilizer by variety treatment was not significant, the data show that Moore responded less than the other varieties to fertilizer treatment. From the no treatment to the highest yielding fertilizer treatment, Moore variety yield increased only 3.5 bushels per acre, while the average increase of

TABLE 4—Grain yields in bushels per acre of five barley varieties, grown with different fertilizer treatments in 1950

Variety	Fertilizer					
	No treatment	0-6-0	0-16-16	4-16-8	4-16-16	Mean
Bay	32.8	34.7	33.5	42.3	45.2	37.7
Wisconsin 38	31.8	31.9	31.9	42.8	39.9	35.7
O.A.C. 21	26.7	36.1	32.5	37.9	31.9	33.0
Montcalm	30.2	40.7	40.2	35.7	42.3	37.8
Moore	35.3	35.6	37.3	37.9	38.8	37.0
Mean	31.4	35.8	35.1	39.3	39.6	.....

the other varieties was 11.6 bushels per acre. The yield increases of the other four barley varieties were similar.

In 1947 and 1948, lodging occurred in the plots to which nitrogen-bearing fertilizer had been applied. Even the most stiff-strawed variety, Bay, lodged when 20 pounds of nitrogen was applied at planting time. None of the treatments caused lodging in 1949 or 1950. In each instance the plots receiving nitrogen with phosphate and potash ripened several days earlier than those receiving fertilizer application without nitrogen.

In 1947 and 1950 the test weight per bushel of barley was not affected by fertilizer treatment. In 1948 and 1949 the test weights were reduced 0.5 and 0.3 pound per bushel, respectively, when nitrogen-bearing fertilizers were applied.

CONCLUSIONS

The data reported herein support the following conclusions:

1. When growing spring barley, especially the varieties Bay, Wisconsin No. 38, or Montcalm, a liberal amount of complete fertilizer should be sown at planting time. Probably nitrogen is the limiting factor on most barley soils. The amount of fertilizer used in these experiments was 500 pounds per acre. Perhaps Moore variety is different than the other varieties in its response to nitrogen.

2. There is no advantage in sowing 4-16-16 fertilizer in place of 4-16-8 analysis.

3. The yield increase of barley obtained from a particular fertilizer treatment will depend a great deal on the previous soil management.

4. The application of complete fertilizer tends to speed up the maturity of barley.

5. The reduced test weight sometimes resulting when fertilizer containing nitrogen is applied to barley is probably not serious enough to keep the grain from qualifying as malting barley.

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RELATIVE EFFECTIVENESS OF VARIOUS INSECTICIDES FOR CONTROL OF ONION THRIPS, UNDER MICHIGAN CONDITIONS

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THE CHIEF INSECT PESTS of onions grown on muck soil in Michigan are the various species of flies known as onion maggots, and the onion thrips, *Thrips tabaci* Lind. The maggots are primarily early season pests, whereas the onion thrips infest onions throughout the growing season, reaching the peak of its activity during August, just prior to harvest.

During growth it is important to maintain the onion leaves free from insects and diseases and in a healthy condition in order to increase bulb size and, hence, yield of salable dry onions. Thrips damage to the foliage is characterized by the appearance of whitened spots particularly on the inner margins of the leaves. The tiny thrips by means of its scraping mouth parts rasps away the surface of the leaf which can bring about withering, blasting and eventual death of the leaf. Thus, if the insects become numerous, which happens especially in dry seasons, the bulbs remain undersized and may become distorted.

In addition to insect troubles, weather and growing conditions in Michigan necessitate the chemical treatment of onions during the growing season for control of the downy mildew disease caused by the organism *Peronospora destructor* Berk. Fortunately, the chemicals thus far used for control of mildew have been compatible with the existing insecticides, and a combined control program has been possible.

[1]Grateful acknowledgment is made of the assistance of Dr. J. Fred Davis, Department of Soil Science, and Robert Gillespie, Foreman of Michigan State College Muck Experimental Farm in carrying out this work. Francis Knight and F. Calvin Swift assisted in making insect counts.

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For years, the insecticidal control of the onion thrips was unsatisfactory, and the use of tartar emetic and sugar sprays during the 1930's was the first approach to a satisfactory control of this pest. However, with the commercial appearance of DDT, Sleesman (1946) and other workers reported that they obtained improved control of onion thrips, resulting in increased yields of onions. Many chlorinated hydrocarbon and phosphorus compounds have become available experimentally and commercially since 1946, and by 1950 it was advisable to carry on experimental treatments to evaluate the newer materials in terms of thrips control. DDT possesses a rather long-term contact poison action, whereas other new chemicals possess contact and fumigation effects of varying periods of duration. The habits of this pest, which spends much time concealed deep between the leaves and in the soil out of the reach of contact insecticides, indicated that use of a fumigating and contact insecticide should improve control.

Ashdown and Watkins (1948) performed chemical analyses of onions treated with dosages of DDT up to 5.25 pounds per acre in dusts, and in the outer scales of cured onions found no residues in excess of 0.2 part per million. Since DDT is known to be the most persistent of the chemicals used in these experiments except for dieldrin, residues on the bulbs were not considered. The possibility of producing off-flavors by insecticides is being investigated.

During the 1949 season, onion thrips populations were high, owing to hot dry weather in July and August. However, in 1950 and particularly in 1951, the weather did not favor onion thrips development. Populations of thrips did not reach damaging proportions during these two years but were sufficient for workers to make accurate comparisons of insecticidal control.

The use of power dusters for application of pest control materials is popular on Michigan muck crops; hence, the chemicals used in this work were applied by high velocity dusters. In all cases where thrips dusts were applied, they also contained fungicidal materials for control of mildew. In 1950 the fungicidal materials were 7-percent metallic copper (from basic copper sulfate) and 30-percent sulfur. In 1951, the copper was replaced with 7-percent dithane, Z-78.

EXPERIMENTAL RESULTS, 1950

In cooperation with the Department of Soil Science, dusting experiments for control of onion maggots and thrips were conducted at the

Muck Experimental Farm. Four early season applications of insecticides were made for control of the flies and four later treatments of the same insecticides with fungicide were made for thrips control. The interval between dustings was approximately 10 days. The results are shown in Table 1. In all cases where examinations for thrips were

*TABLE 1—The effectiveness of various insecticides in controlling thrips on onions, Muck Experimental Farm, 1950**

Treatment material	Concentration, percent	No. of live thrips per 10 plants				Bags of onions per acre†
		July 12	July 18	Aug 1	Aug. 11	
Chlordane.....	5	5	13	61	35	620
Parathion.....	1	20	36	54	48	566
Lindane.....	1	.....	35	99	42	573
Compound 1189‡	5	.....	33	84	106	566
Toxaphene.....	7.5	.....	22	50	85	577
Rotenone.....	0.75	56	58	89	91	539
None.....	.....	98	93	192	178	585

*Dusts were applied at the rate of 50 pounds per acre.
†50 pounds per bag.
‡A chlorinated hydrocarbon compound furnished by the General Chemical Division, Allied Chemical & Dye Corporation.

made, a visual leaf-by-leaf check of 20 or 40 plants selected at random per replicate or treatment (usually four replicates) were made for live thrips. Fractions were reduced to the nearest whole figure.

The data in Table 1 indicate that chlordane, lindane and parathion were effective against thrips. These materials were more effective than were toxaphene, Compound 1189 and rotenone. This difference could be explained by the fact that chlordane, lindane, and parathion possess greater volatility and have a well known fumigant effect whereas the toxaphene, compound 1189 and rotenone are less volatile. Owing to the light thrips infestation, yield apparently was not reduced by their activity.

The properties of dieldrin indicated probable effectiveness of this chemical in thrips control, because of its high toxicity combined with its lasting residual action. In fact Brown (1951) states that dieldrin is the most toxic and residually effective of the present insecticides. Another chemical, EPN-300, which is an organic phosphate chemical was selected for test. This chemical has the high toxicity of the organic phosphate materials and an excellent residual quality (anon., 1951).

Cooperative tests with growers were arranged in order that dieldrin and EPN-300 might be compared with commercially available chemicals. The chemicals were used in the regular growers' programs, and the applications were made at from 10-day to 2-week intervals. Data were taken by methods already described, and the results are shown in Table 2.

TABLE 2—The effectiveness of various insecticides in controlling thrips on onions, by Michigan Commercial Growers, 1950

Location of test	Treatment material	Concentration, percent	No. of live thrips on 10 plants				Dosage in pounds per acre
			July 10	July 19	July 26	Aug. 2	
Stockbridge	DDT (east).....	5	74	76	148	422	40-50
	Dieldrin.....	1.5	13	33	82	382	
	DDT (west).....	5	40	424	618	1,500+	
Parma	Parathion (east) .	1	97	481	.....	500+	40-50
	Dieldrin.....	1.5	77	326	.....	254	
	Parathion (west)	1	53	443	.....	340	
Munith*	DDT.....	5	316	217	.....	.....	50
	Parathion.....	1	.....	.....	152	519	
	EPN-300.....	1	239	150	145	763	

*The grower discontinued using DDT and on July 20 applied parathion.

Dieldrin appeared to be more effective than DDT at the Stockbridge test. A single application of dieldrin prior to the July 10 counting controlled the thrips for more than 2 weeks. At Parma, dieldrin was slightly more effective than parathion. EPN-300 seemed to be slightly better than DDT and possessed about the same effectiveness as parathion for thrips control.

EXPERIMENTAL RESULTS, 1951

The experiment at the Muck Experimental Farm was repeated in 1951, using materials indicated by work in 1950 to be effective and including aldrin, an insecticide known to be chemically similar to chlordane and dieldrin. Populations of thrips in the untreated check plots did not reach a high level and only two dusts were applied, the last of which was made about July 20. On August 1, examinations of all plots for thrips were made; the results are reported in Table 3.

TABLE 3—The effectiveness of various insecticides in controlling thrips on onions, Muck Experimental Farm, 1951

Treatment materials	Concentration, percent	No. of live thrips per 10 plants, August 1
Dieldrin	1.5	30
Aldrin	2.5	38
Lindane	1	50
Chlordane	5	52
EPN-300	1	58
Parathion	1	59
None		80

Dieldrin gave better thrips control than the other chemicals. Aldrin also was somewhat more efficient than were chlordane, lindane, EPN-300 and parathion. These last four chemicals did not give materially different reductions of thrips populations.

EFFECT OF ONION MAGGOT CONTROL MEASURES ON THRIPS POPULATIONS

Since thrips are present in the onion fields during the growing season, the application of insecticides during May and June for control of onion maggots does reduce thrips populations. None of the growers who tested thrips control materials in cooperation with the College had made insecticidal applications for onion maggots; hence, the thrips population reached in their fields might be compared with populations reached at the College Muck Experimental Farm where at least five applications of 5-percent chlordane have been found necessary to insure adequate onion stands. A comparison of the number of thrips shows that considerably more thrips were present on the growers' onions than on onions at the Muck Experimental Farm. This comparison is not experimentally valid, but many field observations and work herein reported support this point.

A further observation was made upon the effect of early season maggot dusting on thrips populations later in the season. Thrips counts were made on replicated plots where dieldrin, chlordane and parathion had been applied on May 23 and June 6. A single thrips dust of a parathion mixture was applied to all plots on July 17.

Table 4 indicates that the number of thrips found in the dieldrin-treated plots was smaller than that found on the plots given 1-percent

TABLE 4—Effect of dusts applied for onion maggot control on the control of onion thrips, Munith 1951

Treatment material	Concentration, percent	No. of live thrips per 10 plants		Dosage in pounds per acre
		August 1	August 6*	
Dieldrin	1.5	121	15	50-60
Parathion	1	174	21	50-60
Chlordane	5	193	33	50-60

*A 1-percent parathion dust was applied to all plots August 5.

parathion or 5-percent chlordane treatments. This would indicate thrips control by maggot dustings since dieldrin has been shown to be the most effective thrips control material. This work was carried on cooperatively in a commercial planting and no untreated check plants were available. The effectiveness of a single application of 1-percent parathion is demonstrated, but the heavy dosage of 50-60 pounds per acre did not eradicate thrips, even at the low populations indicated.

DISCUSSION AND SUMMARY

Several insecticides were compared during 1950 and 1951 for relative effectiveness in reducing the population of onion thrips infesting onions growing in muck soil in Michigan. The most effective of the materials tested at the experimental strengths was 1½-percent dieldrin. This material is known to have a lasting residual quality combined with a high toxicity to thrips. In one test, aldrin used at 2½ percent was quite effective in killing onion thrips. This material has a less lasting residual quality than dieldrin but is more volatile than dieldrin, and has a fumigant action.

Five-percent chlordane, 1-percent lindane, 1-percent parathion and 1-percent EPN-300 all gave somewhat similar reductions of thrips populations. By comparison in field tests, 5-percent DDT was less effective than the above-mentioned materials. Probably because of the habit of the thrips in spending much of its time in protected localities away from toxic residues, the insecticides with a contact and fumigating action were more effective than the contact insecticides except for dieldrin, which is reported to have a very persistent residual action and high toxicity.

Insecticidal dust applications to control onion maggot infestation reduce later thrips populations. Since two of the intermediate stages in the life cycle of the thrips are passed in the soil, residues from the early season dustings should be effective in killing these soil-inhabiting forms. The retention of these insecticides in the soil in Michigan is being studied particularly when heavy dosages of chemicals have been applied to vegetable plantings.

The commercial application of materials mentioned in this work is strictly subject to current labeling regulations. Under no conditions should toxic residual poisons be applied to plants which are to be marketed as green onions.

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HALF-AND-HALF HOMOGENIZED MILK: II. EFFECT OF PROCESSING FACTORS AND ADDED MILK SOLIDS ON THE FLAVOR AND VISCOSITY

By G. M. TROUT and B. R. WEINSTEIN[1]
DEPARTMENT OF DAIRY

IN A PREVIOUS PAPER,[2] data in a series of tables demonstrated how Michigan milk distributors could process half-and-half homogenized milk in order to meet the laws of the state of Michigan concerning the specific gravity requirement. So much interest was shown in this product that additional research was conducted to study the effect of different processing factors and the addition of various milk solids on the flavor and viscosity of the homogenized product.

EXPERIMENTAL

Homogenized milks were produced with the levels of butterfat ranging from 10 to 12 percent. Three types of solids were added to increase the specific gravity of the finished product to 1.029 to 1.033, namely, condensed skimmilk, non-fat dry milk solids (low heat), and a solubilized whole milk protein. Both the non-fat dry milk solids and the solubilized whole milk protein were incorporated in the milk and cream mixture while yet cold and during the slow heating of the mixture up to 120° F.

The pasteurization temperatures were maintained for 30 minutes at 143° F., 150° F., and 160° F. The half-and-half product was homogenized at a pressure of 2,500 pounds per square inch, using both single and two-stage homogenization.

All of the samples were cooled to 40° F. Viscosity measurements were made with a Brookfield viscosimeter. The values are reported as

[1]Present address: Crest Foods Co., Ashton, Illinois.
[2]Trout, G. M., and Weinstein, Bernard. Half-and-half homogenized milk. Mich. Agr. Exp. Sta. Quart. Bul., 33 (2): 67-72. 1950.

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centipoise. Some of the viscosity measurements were made by determining the length of time in seconds that the product required to flow through a standard pipette. The samples were stored at 40° F. for 48 hours, examined organoleptically and viscosity measurements were re-determined.

RESULTS

PASTEURIZATION TEMPERATURE

The results recorded in Tables 1 to 5 inclusive, do not show any relationship between pasteurization temperature and viscosity and the

TABLE 1—The effect of processing factors on the viscosity of a 10-percent fat homogenized milk made without the addition of milk solids. (Specific gravity, 1.023)

Sample No.	Pasteurization temperatures*	Homogenization		Viscosity	
		Pressure	Temperature	0 hours	48 hours
	°F.	P.S.I.	°F.	Centipoise	
1	143	2500	90	4.6	5.9
2	143	2500	100	6.6	8.0
3	143	2500	110	6.4	7.0
4	143	2500	120	6.4	7.6
5	143	2000+500	90	4.8	4.8
6	143	2000+500	100	4.8	5.2
7	143	2000+500	110	4.8	4.8
8	143	2000+500	120	4.8	4.8
9	150	2500	90	7.4	8.6
10	150	2500	100	6.8	8.4
11	150	2500	110	6.6	7.8
12	150	2500	120	6.6	7.4
13	150	2000+500	90	4.8	5.2
14	150	2000+500	100	4.8	4.8
15	150	2000+500	110	4.8	4.8
16	150	2000+500	120	4.8	4.8
17	160	2500	90	5.2	6.2
18	160	2500	100	7.2	8.0
19	160	2500	110	8.0	9.0
20	160	2500	120	6.8	7.6
21	160	2000+500	90	4.8	4.8
22	160	2000+500	100	4.8	4.8
23	160	2000+500	110	4.8	4.8
24	160	2000+500	120	4.8	4.8

*Pasteurized for 30 minutes.

TABLE 2—The effect of processing factors on the viscosity of a 10-percent fat homogenized milk with non-fat dry milk solids added at the rate of 1.4 pounds per 100 pounds of milk. (Specific gravity, 1.029)

Sample No.	Pasteurization temperatures*	Homogenization		Viscosity	
		Pressure	Temperature	0 hours	48 hours
	°F.	P.S.I.	°F.	Centipoise	
1	143	2500	90	6.2	7.2
2	143	2500	100	5.2	6.4
3	143	2500	110	7.2	9.2
4	143	2500	120	6.6	7.6
5	143	2000+500	90	4.8	5.6
6	143	2000+500	100	4.8	5.6
7	143	2000+500	110	4.8	5.2
8	143	2000+500	120	5.2	5.2
9	150	2500	90	6.2	7.4
10	150	2500	100	6.4	7.2
11	150	2500	110	6.4	7.4
12	150	2500	120	6.6	7.0
13	150	2000+500	90	5.2	5.6
14	150	2000+500	100	4.8	4.2
15	150	2000+500	110	5.2	5.6
16	150	2000+500	120	5.6	5.6
17	160	2500	90	7.6	8.8
18	160	2500	100	6.9	7.4
19	160	2500	110	5.8	6.8
20	160	2500	120	6.4	6.8
21	160	2000+500	90	5.2	5.6
22	160	2000+500	100	5.2	5.6
23	160	2000+500	110	4.8	4.8
24	160	2000+500	120	4.8	5.2

*Pasteurized for 30 minutes.

flavor of the finished half-and-half product. This would indicate that the milk processor might well use one of the highest pasteurization exposures for this high-fat milk, thus securing greater pasteurization efficiency, without sacrificing either flavor or viscosity.

HOMOGENIZATION PRESSURE

The results reported in Tables 1 to 5 inclusive, show that the homogenization technique is important if uniformity of viscosity in

the finished product is to be attained. Single-stage homogenization yielded a product that was not uniform in regard to viscosity, whereas. two-stage homogenization brought about a consistent uniformity of viscosity in the finished product. Single-stage homogenization induced varying degrees of fat clumping when the fat content was 10 percent or more and a pronounced increase in viscosity after 48 hours of storage at 40° F. By employing two-stage homogenization, the operators reduced fat clumping to the minimum and there was very little change in viscosity after the 48-hour storage period.

TABLE 3—The effect of processing factors on the viscosity of a 10-percent fat homogenized milk with non-fat dry milk solids added at the rate of 2.1 pounds per 100 pounds of milk. (Specific gravity, 1.032)

Sample No.	Pasteurization temperatures*	Homogenization		Viscosity	
		Pressure	Temperature	0 hours	48 hours
	°F.	P.S.I.	°F.	Centipoise	
1	143	2500	90	4.6	5.0
2	143	2500	100	6.6	6.8
3	143	2500	110	6.9	7.2
4	143	2500	120	7.8	7.8
5	143	2000+500	90	5.2	5.2
6	143	2000+500	100	5.2	5.2
7	143	2000+500	110	5.6	5.6
8	143	2000+500	120	5.6	5.6
9	150	2500	90	6.0	6.4
10	150	2500	100	6.4	6.6
11	150	2500	110	6.6	6.8
12	150	2500	120	6.8	7.0
13	150	2000+500	90	5.2	5.2
14	150	2000+500	100	5.2	5.2
15	150	2000+500	110	5.6	5.6
16	150	2000+500	120	5.6	5.6
17	160	2500	90	6.8	7.8
18	160	2500	100	6.4	6.6
19	160	2500	110	6.4	6.6
20	160	2500	120	7.2	7.8
21	160	2000+500	90	5.6	5.6
22	160	2000+500	100	5.6	5.6
23	160	2000+500	110	5.6	5.6
24	160	2000+500	120	5.6	5.6

*Pasteurized for 30 minutes.

TABLE 4—The effect of processing factors on the viscosity of a 10-percent fat homogenized milk with condensed skim milk added at the rate of 7.2 pounds per 100 pounds of milk. (Specific gravity, 1.029)

Sample No.	Pasteurization temperatures*	Homogenization		Viscosity	
		Pressure	Temperature	0 hours	48 hours
	°F.	P.S.I.	°F.	Centipoise	
1	143	2500	90	5.6	6.4
2	143	2500	100	6.4	7.6
3	143	2500	110	6.0	6.4
4	143	2500	120	6.8	7.6
5	143	2000+500	90	4.8	4.8
6	143	2000+500	100	4.8	5.2
7	143	2000+500	110	4.8	4.8
8	143	2000+500	120	4.8	4.8
9	150	2500	90	6.4	7.2
10	150	2500	100	8.0	9.2
11	150	2500	110	6.0	6.0
12	150	2500	120	7.2	8.0
13	150	2000+500	90	6.0	6.4
14	150	2000+500	100	5.6	5.6
15	150	2000+500	110	4.8	4.8
16	150	2000+500	120	4.8	5.6
17	160	2500	90	7.2	8.4
18	160	2500	100	5.6	5.6
19	160	2500	110	5.6	6.4
20	160	2500	120	7.2	7.6
21	160	2000+500	90	5.6	5.6
22	160	2000+500	100	4.8	4.8
23	160	2000+500	110	4.8	4.8
24	160	2000+500	120	4.8	4.8

*Pasteurized for 30 minutes.

HOMOGENIZATION TEMPERATURE

From the data compiled in Tables 1 to 5, inclusive, the effect of different homogenization temperature was questionable. When single-stage homogenization was used, the viscosity tended to vary non-uniformly with the temperature, whereas two-stage homogenization tended to yield a product that was more consistent in regard to viscosity. The results indicate that there was less difference in the viscosity of the finished product after the 48-hour storage period when two-stage homogenization was used.

EFFECT OF MILK SOLIDS

The results show that the viscosity of half-and-half was increased by the addition of milk solids either in the form of condensed skim milk or as non-fat dry milk solids. However, the increase was not necessarily proportional to the amount of added solids (Tables 1 to 5).

When the solids content of the 12-percent fat, homogenized product was fortified by the addition of 2.1 pounds of solubilized whole milk protein per 100 pounds of finished product, the viscosity of the half-and-half increased approximately 69 percent over that produced by

TABLE 5—The effect of processing factors on the viscosity of a 10-percent fat homogenized milk with condensed skimmilk added at the rate of 10.5 pounds per 100 pounds of milk. (Specific gravity, 1.032)

Sample No.	Pasteurization temperatures*	Homogenization		Viscosity	
		Pressure	Temperature	0 hours	48 hours
	°F.	P.S.I.	°F.	Centipoise	
1	143	2500	90	6.4	7.2
2	143	2500	100	6.8	7.2
3	143	2500	110	5.6	6.8
4	143	2500	120	7.2	8.0
5	143	2000+500	90	4.8	4.8
6	143	2000+500	100	4.8	5.6
7	143	2000+500	110	5.6	5.6
8	143	2000+500	120	4.8	4.8
9	150	2500	90	6.8	7.2
10	150	2500	100	6.0	6.4
11	150	2500	110	6.4	7.6
12	150	2500	120	5.6	6.4
13	150	2000+500	90	4.8	4.8
14	150	2000+500	100	5.6	6.0
15	150	2000+500	110	4.8	4.8
16	150	2000+500	120	4.8	5.6
17	160	2500	90	7.2	8.4
18	160	2500	100	7.2	8.0
19	160	2500	110	6.8	7.2
20	160	2500	120	6.4	7.2
21	160	2000+500	90	4.8	4.8
22	160	2000+500	100	4.8	4.8
23	160	2000+500	110	4.8	5.6
24	160	2000+500	120	4.8	4.8

*Pasteurized for 30 minutes.

the addition of the same amount of non-fat dry milk solids (trials 1 and 2, Table 6). The results also show that the addition of 1.05 pounds of the solubilized whole milk protein per 100 pounds increased the viscosity of the finished product approximately 31 percent over that obtained by the addition of 2.1 pounds of non-fat dry milk solids (trials 7 and 1, Table 6). The addition of 1.57 pounds of solubilized whole milk protein increased the viscosity to 54 percent (trials 8 and 1, Table 6).

TABLE 6—The effect of increasing the solids content of a half-and-half product using a solubilized whole milk protein product. (Pasteurized at 143°F., for 30 minutes, homogenized at 2000+500 p.s.i., average of six trials)

Trial number	Treatment	Fat content	Viscosity		
			0 hours	24 hours	48 hours
		Percent	Seconds	Seconds	Seconds
1	2.1 lb. NFDMS* added per 100 lb. (control)	12	10	12	13
2	2.1 lb. sol. WMP† added per 100 lb.	12	14	23	24
3	2.1 lb. sol. WMP added per 100 lb.	10½	13	17	17
4	2.1 lb. sol. WMP added per 100 lb.	10	11	16	16
5	2.1 lb. of a mixture‡ added per 100 lb.	12	13	20	20
6	2.1 lb. of a mixture§ added per 100 lb.	12	13	17	18
7	1.05 lb. sol. WMP added per 100 lb.	12	13	17	17
8	1.57 lb. sol. WMP added per 100 lb.	12	14	19	20

*Non-fat dry milk solids.
†Solubilized whole milk protein.
‡Solubilized whole milk protein 75% +NFDMS 25%.
§Solubilized whole milk protein 50% +NFDMS 50%.

Even when the fat content of the half-and-half was reduced to 10½ and 10 percent, the viscosity of the finished product was increased markedly by the incorporation of 2.1 pounds of solubilized whole milk protein over that produced by a 12-percent product containing the

same amount of non-fat dry milk solids (31 and 23 percent, respectively, trials 3, 4 and 1, Table 6).

Addition of a blend of 2.1 pounds of solubilized whole milk protein and non-fat dry milk solids, blended at the ratio of 3 to 1 and 1 to 1, increased the viscosity of the finished product approximately 54 and 38 percent, respectively, over that obtained by the use of 2.1 pounds of non-fat dry milk solids (trials 5, 6 and 1, Table 6).

FLAVOR

The samples of the half-and-half homogenized milk were scored to detect the presence of off-flavors after a 48-hour storage period. All of the treatments were found to produce a satisfactory product. The addition of solids seemed to increase the palatability of the finished product, probably as a result of the increase in viscosity.

DISCUSSION AND CONCLUSIONS

One hundred and twenty-eight samples of half-and-half homogenized milk were prepared and studied in regard to processing procedures, viscosity and flavor. The results indicate that pasteurizing temperatures had no significant relationship to the viscosity of the finished product, but from a processing viewpoint, the higher temperature (160° F.) may be desirable. Single-stage homogenization produced varying degrees of fat clumping when 12-percent fat levels were used. This type of homogenization yielded higher initial and final viscosities than did double-stage homogenization. Two-stage homogenization is recommended to secure a product of uniform viscosity.

The addition of non-fat dry milk solids, condensed skimmilk and solubilized whole milk protein increased appreciably the viscosity of half-and-half homogenized milk. A more viscous product was obtained when solubilized whole milk protein was used than when non-fat dry milk solids were used.

The flavors of the half-and-half homogenized milk processed in these studies were above criticism.

SOME FACTORS AND THEIR INTERACTIONS AFFECTING THE YIELD OF SWEET CORN GROWN ON ORGANIC SOIL

By J. F. DAVIS
DEPARTMENT OF SOIL SCIENCE

HIGH YIELDS of excellent quality sweet corn can be produced on muck[1] provided good soil management practices are followed, as shown by the data obtained at the Muck Experimental Farm, Michigan State College, for the past 6 years.[2]

The following factors, with some factor interactions, have been studied: a) rate of fertilizer application, b) date of planting, c) plant population, d) heat units, and e) varieties.

Results from previous investigations on factors associated with sweet corn production on muck soils indicate that from 500 to 1000 pounds per acre of either an 0-10-20 or an 0-10-30 fertilizer is needed for well-drained mucks, and if the muck is not well-drained, either a 3-12-12 or 3-9-18 fertilizer is recommended. In some instances, 5 percent of copper sulfate added to the fertilizer mixture is of value, especially if the soils have a pH of 6.5 or below. If the soil reaction is above pH 6.5, 10 percent manganese sulfate should be included in the fertilizer mixture. In some instances 5 percent borax added to the fertilizer, regardless of the soil pH, will be beneficial. If the fertilizer contains micro-nutrient elements, especially borax, it should be applied with a grain drill in 7-inch bands 3½ to 4 inches deep ahead of planting to prevent possible injury to stand. A planting depth of 1½ to 2 inches is satisfactory.

Extreme care should be taken to keep the sweet corn free from weeds and prevent weeds from going to seed. A weeder can be utilized to good advantage if used when weeds are small. Sweet corn from 12 to 16 inches high can be safely cultivated with a weeder provided

[1]The term "muck" is used to denote both muck and peat soil.
[2]Data for the period 1946-48 inclusive were obtained jointly by Dr. P. M. Harmer and the author.

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the weeder is operated at a relatively low rate of speed. The conventional type of cultivator may also be used successfully for weed control. However, deep cultivation should be avoided in order to prevent serious root pruning. It is suggested that a grower obtain the latest information regarding the control of weeds in sweet corn by chemical methods. This information can be obtained from the Michigan State College Bulletin Office.

EXPERIMENTAL RESULTS

The effect of rate of fertilizer application, date of planting and variety on the yield of sweet corn produced on muck soils is illustrated by data presented in Tables 1, 2, and 3. Two rates of 0-10-30 fertilizer, 500 and 1,000 pounds per acre, applied in bands 7 inches apart, $3\frac{1}{2}$ inches deep with a grain drill, were used. Three varieties, Gold Rush and Carmel Cross, early varieties, and Golden Cross, a later variety, together with three different dates of planting were studied in 1949 and 1950.

Three dates of planting, May 25, June 4, and June 21 in 1949, and May 29, June 8, and June 16 in 1950 were made to study the effect of planting date on yield. No yields were obtained from the June 21 planting in 1949 because of severe damage by pheasants. However, it was estimated that the yield for this planting date was approximately 35 percent less than the yield of plots planted on June 4.

As shown by the data in Tables 1, 2, and 3, in two out of the three years, there were no appreciable differences in yields between plots given either 500 or 1,000 pounds of fertilizer. However, in 1949 the yields of plots receiving the heavier application of fertilizer were, on the average, 0.7 ton per acre higher. There was an interaction between the effect of rate of fertilizer application and variety. In other words, the two varieties did not respond the same to increases in rate of fertilizer application. The Gold Rush variety, planted May 25, yielded 7.7 and 6.1 tons per acre, respectively, with the 1,000- and 500-pound per acre rates of fertilizer. The corresponding yields for the June 4 planting were 8.7 and 7.8 tons. The Golden Cross variety, planted May 25, yielded less with 1,000 pounds of fertilizer than with the 500-pound rate. The yields of the plots planted June 4 averaged 6.4 tons for the 1,000-pound rate and 5.7 tons for the 500-pound rate. For this particular year apparently the Gold Rush variety made more efficient use of the extra fertilizer than did the Golden Cross.

TABLE 1—The effect of rate of fertilizer application, date of planting, and variety on the yield of sweet corn. Muck Experimental Farm, 1950

Variety	Date of planting	Pounds* 0-10-30	Yield per acre†	
			Tons	Dozen ears
Carmel Cross	May 29	500	8.6	1,998
		1,000	8.8	2,066
	June 8	500	6.2	1,429
		1,000	6.7	1,595
	June 16	500	3.8	940
		1,000	3.9	961
Golden Cross	May 29	500	4.7	1,192
		1,000	4.6	1,166
	June 8	500	4.3	986
		1,000	4.2	983
	June 16	500	3.1	824
		1,000	3.0	889
Average of all variety comparisons:				
Carmel Cross			6.3	1,498
Golden Cross			4.0	1,007
L.S.D.‡, 5-percent level			1.1	.....
Average of all planting date results:				
May 29			6.7	1,606
June 8			5.4	1,248
June 16			3.4	904
L.S.D., 5-percent level			0.9	.....
Average of all rate data results:				
500 lb. 0-10-30			5.1	1,228
1,000 lb. 0-10-30			5.2	1,277
No significant difference				

*Fertilizer applied in 7-inch bands, 3½ inches deep with a grain drill.
†Yields based on snapped corn.
‡Least significant difference.

As indicated by the data presented in Tables 1 and 3, it was more economical to use 500 rather than 1,000 pounds of fertilizer per acre on sweet corn in 1950 and 1951. In general, the number of ears harvested varied according to the weight per acre, indicating that increasing the rate of fertilizer did not increase the weight per ear but that any differences in yield were due to increases in the number of ears per acre.

As shown in Tables 1 and 2, an early variety of corn such as Carmel Cross or Gold Rush will outyield some of the later maturing ones. Early varieties should be grown in preference to the later varieties on muck soils that have a similar climatic environment to that of the Muck Experimental Farm.

Another important factor was the date of planting. From the data obtained it seems that about June 1 is the best time for planting sweet corn in the vicinity of East Lansing, for both early and late varieties. In 1950, with Carmel Cross, there was a daily reduction in yield of approximately one-quarter ton from the May 29 to the June 8 planting. As shown in Table 1, a significant interaction between date of planting and variety was obtained. Date of planting had a greater effect on

TABLE 2—The effect of rate of fertilizer application, date of planting, and variety on the yield of sweet corn. Muck Experimental Farm, 1949

Variety	Date of planting*	Pounds† 0-10-30	Yield per acre‡	
			Tons	Dozen ears
Gold Rush	May 25	500	6.1	1,481
		1,000	7.7	1,774
	June 4	500	7.8	1,985
		1,000	8.7	2,035
Golden Cross	May 25	500	5.2	1,718
		1,000	4.8	1,570
	June 4	500	5.7	1,745
		1,000	6.4	1,775
Average of all variety comparisons:				
Gold Rush			7.6	1,819
Golden Cross			5.5	1,702
L.S.D.§, 5-percent level			0.4	.....
Average of all planting date results:				
May 25			5.9	1,885
June 4			7.2	1,636
L.S.D., 5-percent level			0.3	.....
Average of all rates data results:				
500 lb. 0-10-30			6.2	1,732
1,000 lb. 0-10-30			6.9	1,789
L.S.D., 5-percent level			0.7	.....

*June 21 planting partially damaged by pheasants. Undamaged plots yielded approximately 35 percent less than the plots planted June 4.

†Fertilizer applied in 7-inch bands 3½ inches deep with a grain drill.

‡Yields based on snapped corn.

§Least significant difference.

TABLE 3—The effect of rate of fertilizer application and plant population on the yield of Carmel Cross sweet corn. Muck Experimental Farm, 1951

Treatment, pounds* 0-10-30	Plants per acre	Yields per acre†		
		Tons	Average weight per ear (lb.)	Dozen ears
500	18,669	8.3	0.799	1,717
500	14,520	7.0	0.773	1,495
1,000	18,669	8.3	0.795	1,774
1,000	14,520	6.6	0.803	1,365
Rate per acre (average of all data):				
500 lb. 0-10-30		7.7	No significant difference	
1,000 lb. 0-10-30		7.5		
Number of plants per acre:				
(28" x 36") 18,669		8.3		
(36" x36") 14,520		6.8		
L.S.D.‡, 5-percent level		0.6		

*Fertilizer applied in 7-inch bands 3½ inches deep with a grain drill.
†Yields based on snapped corn.
‡Least significant difference.

yields of Carmel Cross than on the yields of Golden Cross. However, no significant date of planting x variety interaction was found between the varieties Gold Rush and Golden Cross in 1949.

The effect of plant population on yield is demonstrated by the data in Tables 3 and 6. Increasing the number of plants per acre from an average of 14,520 to 18,669 increased the yield 1.5 tons per acre in 1951 and approximately 1 ton per acre in 1948. In these trials the hills were spaced 36 inches by 36 inches and 28 inches by 36 inches, with three stalks per hill.

The data on the performance of a number of sweet corn varieties for three years are reported in Tables 4, 5, and 6. A wide difference is noted in earliness, yield, average weight of ears, and number of ears per hill among the several varieties. Generally speaking, low quality is associated with earliness. However, an early variety of corn has the advantage in being able to partially overcome the danger of an early fall frost. For example, high yields of sweet corn were obtained from only three of twelve varieties planted on June 15 in 1946, owing to the early fall frost. These varieties were North Star, Seneca Dawn and Carmel Cross. Of the three, Carmel Cross has consistently been of the best quality. The Gold Rush variety, which is similar to the

TABLE 4—Yield of sweet corn varieties. Muck Experimental Farm, 1946

Variety*	Tons per acre†	Weight per ear (lb.)	Days to harvest
North Star	6.7	0.69	80
Seneca Dawn	7.5	0.73	80
Carmel Cross	5.4	0.70	83
Seneca Golden	4.6	0.59	81
Mid Golden	3.0	0.52	85
Difference required for sign	1.3		

Planting date—June 15. Fertilizer—1,000 lb. 0-10-30 per acre. Spacing—28" x 36" (3 stalks per hill).
*No yields were obtained from the following varieties due to early frosts: Erie, Golden Cross, Hoosier Bantam, Oto, Seneca Chief, Lincoln and Tendermost.
†Yields based on snapped corn.

Carmel Cross, also shows considerable promise for muck soils. With respect to maturity and quality, the Golden Cross Bantam and similar varieties produce well on muck during seasons in which an early fall frost does not occur before they mature. Nevertheless, the maturity

TABLE 5—Yield of sweet corn varieties. Muck Experimental Farm, 1947

Variety	Tons per acre*	Weight per ear (lb.)	Days to harvest
Gold Rocket	4.7	0.55	76
Spancross	5.7	0.53	76
Seneca 60	4.7	0.43	76
North Star	5.6	0.56	76
Marcross	5.2	0.66	76
Seneca Dawn	6.2	0.70	76
Seneca Golden	5.5	0.60	78
Carmel Cross	5.7	0.65	80
Gold Rush	5.8	0.63	78
Iogold	5.9	0.48	80
Lee	5.3	0.72	83
Mid Golden	4.8	0.50	82
Minn. Hybrid 202	5.0	0.43	82
NK J9	4.7	0.48	83
Golden Glory	5.0	0.55	83
NKE 5	3.9	0.53	83
Golden Cross	5.1	0.63	85
NK 407	5.1	0.60	85
Ioana	5.5	0.72	87
Seneca Chief	4.5	0.52	85
Difference required for significance	1.1	0.03	

Planting date—June 6. Spacing—28" x 36" (3 stalks per hill). Fertilizer—1,000 lb. 0-10-30 per acre.
*Yields based on snapped corn.

factor is important for the grower to consider when selecting a variety, because a small difference may mean the difference between a profitable crop and a complete failure on many muck soils. The type of processed product, whole kernel or cream style, could also modify to some extent the adaptability of a variety for muck.

Another important factor to consider in selecting a variety is that of suckering (tillering). This factor will become increasingly important as more acres are harvested mechanically. The data in Table 6 show a marked variation between the tillering habit of different varieties. Seneca Dawn produced fewer tillers than any other variety tested.

TABLE 6—Yield of sweet corn varieties and the effect of spacing on yield and tillering of sweet corn. Muck Experimental Farm, 1948

Variety	Tons per acre*		Weight per ear (lb.)		Stalks per hill		Days to harvest
	(28"x36")	(36"x36")	(28"x36")	(36"x36")	(28"x36")	(36"x36")	
North Star.....	7.2	5.5	0.62	0.62	7.6	5.9	82
Golden Rocket	4.1	3.0	0.61	0.57	6.1	7.0	84
Seneca Dawn..	7.2	6.9	0.75	0.85	4.8	7.0	84
Marcross.....	6.2	5.8	0.73	0.73	8.3	10.1	84
Carmel Cross..	7.6	6.4	0.79	0.80	8.4	9.3	87
Gold Rush....	8.1	7.0	0.71	0.64	8.2	7.6	87
NK5001.....	6.7	5.7	0.59	0.61	9.8	9.8	89
Lee.....	6.0	5.1	0.77	0.75	6.7	6.5	89
Mid Golden...	5.2	4.5	0.56	0.51	8.6	7.4	89
S–2.....	7.2	6.4	0.68	0.67	11.0	11.1	91
NK405.....	7.5	7.2	0.88	0.81	10.1	12.0	91
Golden Glory..	7.8	6.1	0.67	0.67	6.7	8.7	94
Golden Bounty	7.2	7.0	0.68	0.74	7.2	8.5	94
Golden Cross (Robson)....	7.7	5.6	0.69	0.68	9.1	10.2	94
Golden Cross (Asgrow)....	8.0	5.8	0.73	0.63	8.9	10.8	94
Ioana.....	6.2	5.3	0.76	0.76	6.9	8.1	97

Planting date—May 29. Fertilizer—1,000 lb. 0-10-30 per acre.
*Yields based on snapped corn.

It is not possible to state accurately that a certain variety of corn will be ready for market after a specified number of days from planting. As brought out by the data presented in Table 7, the number of days to maturity is influenced greatly by the season; it may vary as much as 20 days in successive seasons. One of the principal reasons for this variation is the difference in temperatures from one season to another. The data in Table 7 show the number of heat units required

to mature different varieties of sweet corn in two different growing seasons. In making the calculations for the values shown in Table 7, temperatures (° F.) were taken at four different places as follows: a) 8 inches above the surface of the ground, b) at the soil level, c) 3½ inches below the soil surface, and d) 7 inches below the soil surface. These units represent the cumulative values for each day. The number for any one day is calculated by the following formula:

$$\text{Heat units per day} = \left[\left(\frac{\text{maximum temp.} + \text{minimum temp.}}{2}\right) - 50\right] 24$$

A base temperature of 50 degrees is used because it is considered that for all practical purposes sweet corn does not grow at temperatures below 50°.

As noted in Table 7, there is fair agreement between the number of heat units required to mature a crop of sweet corn with different

TABLE 7—The relationship between varieties and date of planting to the number of heat units required to produce a crop of marketable sweet corn. Muck Experimental Farm, 1949 and 1950

Variety	Date of planting	Days to harvest	Date of harvest	Thermometer position relative to soil level			
				8" above	Soil level	3½" below	7" below
				(*heat units*)			
1949							
Gold Rush ...	May 25	79	Aug. 11	38,916	59,412	33,048	17,352
	June 4	73	Aug. 15	37,956	57,060	33,252	18,228
Golden Cross.	May 25	83	Aug. 15	40,896	62,052	34,956	18,540
	June 4	79	Aug. 21	39,672	61,296	35,796	19,908
1950							
Carmel Cross.	May 29	92	Aug. 28	37,116	60,660	34,236	16,800
	June 8	84	Aug. 30	34,212	57,408	32,712	16,920
	June 16	84	Sept. 7	33,132	56,928	32,256	17,616
Golden Cross.	May 29	102	Sept. 7	39,780	65,640	37,308	19,008
	June 8	99	Sept. 14	38,832	65,064	37,334	20,172
	June 16	96	Sept. 19	36,828	62,604	35,796	19,896
Average for two years:							
Gold Rush and Carmel Cross.....				36,266	58,294	33,101	17,383
Golden Cross.....				39,202	63,331	36,238	19,505

$$\text{Heat units per day} = \left[\left(\frac{\text{maximum temp.} + \text{minimum temp.}}{2}\right) - 50\right] \times 24$$

dates of plantings and with different seasons. It is also shown very conclusively that the two varieties, the early and late, require different numbers of heat units. The data also show that the temperatures at any one of the four levels taken may be used in calculating the number of heat units required by any particular variety.

This subject of heat units has received a lot of attention from commercial canners for both peas and sweet corn, in connection with the spacing of planting dates so as to maintain more orderly harvesting operations at the time of processing the crop.

SUMMARY

According to the results obtained in the past 6 years at the Muck Experimental Farm, Michigan State College, from 500 to 1,000 pounds of an 0-10-30 fertilizer has produced high yields of sweet corn of good quality.

Sweet corn should be planted about June 1. Delay in planting after June 1 may result in as much as 0.25 ton reduction in yield per day. Extremely early plantings are hazardous because there is always danger from late spring frost on muck soils. However, if the planting date is delayed there is considerable danger in an early fall frost.

Higher yields of sweet corn are obtained with plants spaced 28 inches by 36 inches in hills than with a 36-inch by 36-inch spacing. If sweet corn is planted in hills, three plants per hill are recommended.

A wide difference in earliness, yield, weight of ear, and number of ears is found among varieties. An early variety of good quality, such as Carmel Cross, is recommended.

It cannot be stated that a certain variety of corn will be ready for use in a specified number of days after planting. The data show that, for the same variety, a variation as much as 20 days may be observed in successive seasons.

In the commercial production of sweet corn for canning, the use of heat unit data can be of practical value in helping to improve the quality of the processed product, through allowing a more orderly harvesting operation during the processing season.

LEAF HOPPER CONTROL TO PREVENT THE SPREAD OF THE VIRUS DISEASE ASTER YELLOWS IN COMMERCIAL LETTUCE PRODUCTION: PART II

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WORK ON THE PROJECT for controlling the six-spotted leaf hopper (*Macrosteles divisa* [Uhler]) in commercial lettuce plantings was started in 1950[1] and continued in 1951. In 1950 protection of the lettuce from attack by the six-spotted leaf hopper, and there-by the transmission to a limited extent of the virus disease, aster yellows, was accomplished by the treatment of the lettuce only. The work in 1951 was intended to be a repetition of the work in 1950 and to determine the possible control value of spraying the weed borders about the planting.

This treatment procedure was tried because of the habits of the leaf hopper. The six-spotted leaf hopper appears in the early spring and feeds on weed host plants and early cultivated crops. Since the fields of muck where the lettuce is planted are cleanly cultivated, there is practically no food source for the leaf hoppers in the field until the lettuce plants come up. When the lettuce plants appear the leaf hoppers migrate from the weed borders surrounding the fields to the lettuce as the new food source becomes available.

As in 1950, the cooperative experiments were carried out at the Trapp and Sons farm at Beulah, Michigan. The tests were started on June 21, 1951, and terminated with the harvest of the lettuce crop on August 16, 1951. The field was planted in 48 rows, each 300 feet long. The distance between the rows was 34 inches, and the distance between plants in the rows was 14 inches. The width of the field extended north and south, and the rows were planted in an east-to-

[1]Hoffman, J. R. Leaf hopper control to prevent the spread of the virus disease aster yellows in commercial lettuce production. Mich. Agr. Exp. Sta. Quart. Bul., 33 (3): 201-3, Feb. 1951.

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west alignment. One-half (south) of the field was planted to variety 456, and the north half of the field to the variety Great Lakes. The plots were arranged so that, starting with the rows of Great Lakes to the North, the first eight rows were left untreated and served as a check, the next eight rows were treated with parathion sprays, the next eight rows were treated with Experimental Insecticide 4049.[2] The first eight rows of 456 bordering the Great Lakes lettuce were treated with 4049 sprays, the next eight rows were treated with parathion sprays, and the last eight rows were left untreated to serve as a check.

The parathion sprays were prepared at a dosage of 1 pound of 15-percent wettable powder to 100 gallons of water. Experimental Insecticide 4049 sprays were prepared at a rate of 1 pound of the 25-percent wettable powder to 100 gallons of water. The spray applications were applied with an "Iron Age" sprayer mounted on an Oliver "Cletrack." A boom-type nozzle arrangement allowed for the spraying of eight rows at one time, and the sprays were applied at a pressure of 375 pounds at a rate of application of 25 gallons per acre. The sprays were applied to the lettuce on June 21, July 6, and July 20.

The weed borders were treated with parathion-DDT sprays, either combined or alone at approximately the same rate of application as the lettuce plants. Possible injury to the weeds by the sprays was ignored. Table 1 gives the spray schedule and concentrations used for the weed border sprays to control migrations of leaf hoppers into the lettuce planting.

Counts of 500 plants of each variety and each treatment and the control were taken at harvest time and the number of yellowed plants was noted. These results are shown in Table 2.

A comparison of the treated plots with the untreated plots showed the treated plots to have a lower incidence of aster yellows, which may be attributed to the application of insecticides for the control of the six-spotted leaf hopper, the vector for this virus disease. Since the borders around the entire test plots of lettuce were treated for leaf hopper control, it is felt that the results of these tests gave a definitely lower reading than would have been observed had no border sprays been applied. This was further illustrated in a field where no border spray had been applied for a period of 4 weeks. In this field the incidence of yellows was estimated at not less than 50 percent of the crop by the grower.

[2]An insecticide of the American Cyanamid Co., New York, N. Y.

TABLE 1—Spray schedule and spray concentrations used for weed borders surrounding lettuce plantings

Date	Insecticide	Quantity per 100 gallons of water
May 24	Parathion	1 lb. 15% wettable powder
June 5	Parathion	1 lb. 15% wettable powder
June 13	Parathion	1 lb. 15% wettable powder
	DDT	2 lb. 50% wettable powder
June 21	DDT	1½ pt. 25% emulsifiable
July 6	DDT	1½ pt. 25% emulsifiable
July 21	Parathion	1 lb. 15% wettable powder
	DDT	2 lb. 50% wettable powder
July 28	DDT	1½ pt. 25% emulsifiable
August 3	DDT	1½ pt. 25% emulsifiable
August 11	Parathion	1 lb. 15% wettable powder

TABLE 2—Aster yellows symptoms in insecticide-sprayed lettuce plants (500 plants each treatment)

Variety of lettuce	Treatment	Number of plants showing yellows symptoms	Percent of plants showing yellows symptoms
Great Lakes	Parathion	37	7.4
	4049	37	7.4
	Untreated	53	10.6
456	Parathion	31	6.2
	4049	33	6.6
	Untreated	58	11.6

SUMMARY AND CONCLUSIONS

The application of parathion or Experimental Insecticide 4049 to field-grown lettuce, supplemented with the spraying of the surrounding weed borders with heavy applications of parathion and DDT gave substantial control of the six-spotted leaf hopper (an insect vector of the virus disease aster yellows) and lowered the incidence of aster yellows in the lettuce crop produced. The results indicate that the

treatment of the weed borders around the field should not be ignored as a method of successful control of the leaf hoppers and the increase in production of salable head lettuce. Discussions with the cooperating grower showed that the control measures were commercially desirable and reasonable in cost.

Further tests are planned in the development of effective controls for the six-spotted leaf hopper and the reduction of the incidence of aster yellows in the commercial production of field-grown lettuce.

PRELIMINARY OBSERVATIONS ON THE EFFECT OF 2,4-D AND 2,4,5-T ON ASPEN

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THE MANUFACTURE of quality pulp and paper products requires that pulpwood be free from bark. Most pulp mills achieve this with mechanical or hydraulic barking machines. Such equipment is very expensive and requires large quantities of power. The disposal of bark at the mill also presents a considerable problem.

Whenever possible, therefore, pulpwood peeled in the woods is preferred. However, bark can be removed in the woods easily only during the relatively short "sap-peeling" season, which extends from the time the new leaves appear in the spring until late May, June or early July, depending on the species, weather conditions and locality. During this period of active growth the cambium is turgid and the newly formed cells are thin-walled, thus they easily rupture under any kind of mechanical stress. Later in the growing season the cambial cells lose some of their turgidity, and the newly formed cells become thicker-walled. The bark clings more readily to the surface of the wood; hence, there is no longer a region of easy cleavage present. Trees cut during this period of growth cannot be readily peeled.

The possibility of prolonging the "sap-peeling" season and perhaps improving upon the woods peeling operations by killing trees with chemicals has received considerable attention. The idea of killing trees with chemicals dates back at least 25 years. As a silvicultural tool, chemical poisoning was first used for removing undesirable species and inferior trees or as a control measure to check the spread of disease or insects.

When chemical poisoning is employed to facilitate bark removal, the purpose is not merely to kill a tree. Killing of the tree is only incidental; the main purpose of the treatment is to cause the bark to retain the easy peeling characteristics of the "sap-peeling" season.

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Large-scale experiments to evaluate the effectiveness of such treatment for bark removal were first undertaken by the Canadian Forest Products Laboratory at Ottawa in 1943, at the request of the Pulp and Paper Association of Canada (3). Since then the method has been successfully employed on a large scale in a number of pulpwood operations. The most notable example in the United States is at the Armstrong Forest Company operations in Pennsylvania (1).

Although a large number of chemicals have been tried for this purpose, the greatest success has been achieved with sodium arsenite. But, because of the hazards involved in the use of this extremely toxic chemical, search is continuing for an equally effective but less dangerous chemical. Among those considered promising are metallic salts and esters of 2,4-dichlorophenoxyacetic and 2,4-5-trichlorophenoxyacetic acids (commonly abbreviated to 2,4-D and 2,4,5-T).

OUTLINE OF THE PROJECT

The purpose of this report is to describe the results of field experiments to determine the effectiveness of 2,4-D and 2,4,5-T on bark removal in aspen. The experiments were largely confined to trembling aspen (*Populus tremuloides* Michx.), although largetooth aspen (*Populus grandidentata* Michx.) was also included.

The field plots were established at the Dunbar Forest Experiment Station, Sault Ste. Marie, Michigan, and on the properties controlled by the Patten Logging Company, Amasa, Michigan, the William Bonifas Lumber Company in Menominee County, Michigan, and the American Box Board Company near Filer City, Michigan. The cooperation of these companies was enlisted in order to expedite field experimentation and to enlarge the scope of the program possible to carry out in one growing season.[1] The Dow Chemical Company furnished the materials used in these experiments.

PROCEDURE

Ten or more trees were treated at each application, and the treatments were made at about 15-day intervals. As far as possible only trees of merchantable size, containing at least one pulpwood stick, were used. Diameters of treated trees ranged from 6 to 10 inches

[1]The authors wish to express their appreciation to the above-mentioned companies for carrying out these experiments at their own expense, and to the following individuals for executing this work and for collecting the data: Mr. T. M. Kataja, American Box Board Company; Mr. M. L. Strengberg, Patten Logging Company, and Mr. M. L. Argetsinger, William Bonifas Lumber Company.

D.B.H. (diameter at breast height). The treated trees were inspected periodically through the growing season, and the final inspection was made in late August or in September.

METHODS OF APPLICATION

Three methods of application of chemicals were used:

a) *Trunk spray.* Trunks were sprayed from ground (or snow) level to a height of 1, 3 and 8 feet. All sides of the stem were covered thoroughly to the point of runoff.

b) *Girdling.* Stems were girdled at some convenient height from the ground for a distance of 6 to 8 inches and the exposed area sprayed or painted with the chemical.

c) *Frill girdling.* A frill was made with an axe, around the base of the tree, and enough solution was poured from a can to fill it completely.

CHEMICALS USED

The following chemicals were used by all the cooperators: 2,4-D amine salt (Dow No. 40A and 2,4-D ester (Dow Esteron No. 44). In addition, 2,4,5-T ester (Esteron 245) was also used at Dunbar.

Two of the cooperators, the Bonifas Lumber Company and the American Box Board Company used water solutions, while at the Dunbar Forest Experiment Station and Patten Logging Company the solutions were prepared with diesel oil. In all instances only a 6000 p.p.m. concentration was used. This was prepared by adding 2.56 fluid ounces of concentrated 2,4-D amine salt (Dow No. 40A) to one gallon of diesel oil or water; for the other solutions, 2.08 fluid ounces of Dow Esteron 44 and 245 were used.

DISCUSSION

The cooperators using water solutions, i.e. the William Bonifas Lumber Company and the American Box Board Company, reported negative results at the time of the final inspection in the fall. It has been concluded that the waxy surface of aspen bark permitted only a small amount of water solution to be absorbed, or that the solution was washed off before the chemical could be absorbed into the sap stream. The discussion that follows, therefore, is confined to a description of results obtained with the oil solutions on the remaining experimental plots.

DUNBAR FOREST EXPERIMENT STATION

Discussion of Previous Treatments—Work at the Dunbar Forest Experiment Station during the past 6 years in the field of chemical control of undesirable trees and shrubs provided a good background for this project. Much of this work had been with shrubs such as hazel, alder and willow and such trees as red maple and cherry. Some of the results thus obtained are of value in this project.

Examination of a group of red maple trees, stem sprayed in July 1950 with 2,4-D and 2,4,5-T esters in concentrations of 6000 p.p.m. and greater, indicated that all trees were dead and that there was considerable evidence of bark loosening. In many cases the bark was cracked and could be easily peeled by hand. A group of small aspen trees treated in 1949 with 2,4-D and 2,4,5-T esters were all dead in 1950, and there was considerable evidence of bark loosening and peeling when these trees were examined in 1951. This bark-loosening tendency of certain hardwoods after 2,4,5-T basal stem spray has also been reported by Chaiken (2).

It should be noted that in almost all instances, the examinations during the growing season following that when treatment was made showed more pronounced results than were revealed by inspection during the year when applications were made.

1951 Treatments—Applications were started on March 15 and continued through the middle of July. One treatment in early May was omitted because of bad road conditions.

Two methods of application were used: The spray method to a height of 3 feet, and the frill girdle. Three solutions in diesel oil were employed in concentrations of 6000 p.p.m.: 2,4-D amine salt, 2,4-D ester, and 2,4,5-T ester.

The field work was complicated by a severe infestation of the forest tent caterpillar. This infestation began during the first week of June, and by the end of that month aspen was entirely defoliated. By the middle of July practically all of the defoliated trees had put out a new set of leaves. This second set, however, was less dense, in many instances representing only about one-half of the original leaf area.

Side Experiments—In addition a number of side experiments were also made to try out various ideas that may conceivably result in improvement of present methods.

Double-strength solutions of the same three formulations were used and the results indicated a much faster killing effect. The relative effectiveness of the three solutions was the same as indicated in Tables 1 and 2.

The Cornell tool was used with sodium arsenite and the three test formulations. The results were negative for all except sodium arsenite, in which case an immediate kill occurred.

The three solutions were applied to the base of the tree and exposed roots, by pouring from a tallow pot. Results were negative except in one case with ester 2,4,5-T. About one gallon of solution per 10 trees was used.

Several trees were frill girdled without further treatment. Others were treated with diesel oil alone and with sodium arsenite. Results were negative, except for sodium arsenite.

Inconsistent results were obtained with the Council axe, followed by sodium arsenite application. Some trees died quickly, while others showed injury only, at the time of inspection.

Patten Logging Company—Applications were started on April 30 and continued at about 15-day intervals through the middle of July.

Two methods of application were employed: girdling followed by spraying, and stem spraying. Amine salt and 2,4-D ester in diesel oil were used, at a concentration of 6000 p.p.m.

RESULTS

The data, including results of a final inspection in the fall of 1951, are presented in Tables 1 and 2. Again, it should be pointed out that experience has shown that all or most of the trees listed as injured or dying at the end of the first season will probably be dead the following growing season. The action of 2,4-D and related compounds is rather slow, and sometimes there is no evidence of injury for 2 or more months following application of the chemical.

From examination of the data in the tables, it is evident that the stem spray method is superior to the frill girdle treatment and at least equally effective to that of girdling and spraying.

Of the chemicals employed in these experiments, the best results on the basis of the 1951 fall examination were obtained with 2,4,5-T and the poorest and least consistent with amine salt. A quicker kill is also indicated for 2,4,5-T in comparison with 2,4-D ester.

TABLE 1—Stem-spray treatment

Treatment date	2,4-D amine salt (Dow 40A)								2,4-D ester								2,4,5-T ester			
	Dead		Nearly dead		Injury evident		Healthy		Dead		Nearly dead		Injury evident		Healthy		Dead	Nearly dead	Injury evident	Healthy
	D*	P†	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	D	D	D
3/16/51	1				3		6		7						2		8	1		1
4/4/51							5		6		1		1				10			
4/18/51	1		1				7		2		1		7				8		2	1
4/30/51				2		4		4		1		1		8						
5/12/51		1		3		4		1		3		3		3						
5/17/51							11		9				1				9	1		
5/28/51						4		6				3		6						
6/4/51					2		8		5		2		2		1		9		3	
6/14/51		1				4		5		7		1		2						
6/15/51					2		9		3		1		7				6	2	4	
6/27/51					1		9		5		1		4				10			
7/11/51		1		6		1						1		4		1				
7/17/51							10		7		1		2				10			
Total	2	3	1	11	8	17	65	16	44	11	7	9	24	23	3	1	70	4	9	2
Percent	2.5	6	1	24	10.5	36	86	34	56	25	9	21	31	52	4	2	82.3	5	10.5	2.2
Average percent for D and P	4		10		20		65		45		13		39		3		82.3	5	10.5	2.2

*D—Dunbar Forest Experiment Station—Last examination date 8-28-51.
†—Patten Logging Company. Last examination date 9/5/51.

TABLE 2—Girdling and spray treatment

Treatment date	2,4-D amine salt (Dow 40A)								2,4-D ester								2,4,5-T ester			
	Dead		Nearly dead		Injury evident		Healthy		Dead		Nearly dead		Injury evident		Healthy		Dead	Nearly dead	Injury evident	Healthy
	D*	P†	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	D	D	D
3/16/51							9				2		4		4		1			9
4/4/51							10								10					9
4/18/51							8								11			1	4	9
4/30/51						9		1		1				9						
5/12/51				1		9						1		9						
5/17/51			1		5		4		5				4		2		7	1	3	
5/28/51				2		8				1		4		5						-
6/5/51					1		9		2				4		6		1		3	6
6/14/51		2		1		5		2						8		2				
6/15/51					1								2		7		1		1	10
6/27/51							10		1		1		4		4				6	4
7/11/51		2		2		6						1		7		2				
7/17/51							10								10				2	8
Total	0	4	1	6	7	37	69	3	8	2	3	6	18	38	54	4	10	2	19	55
Percent D frill-girdled	0		1		9		90		9.5		3.5		22		65		12	2	22	64
Percent P girdled	8		12		74		6		4		12		76		8					

*D—Dunbar Forest Experiment Station—Frill girdling with an axe was used on this plot. Final date of inspection 8/28/51.
†P—Patton Logging Company—Final date of inspection 9/5/51.

There was little evidence of bark loosening at the time of the final inspection in the fall of 1951. On some of the dead trees the bark appeared to have changed to a yellow or light brown, but this change in color had no recognizable effect on the tightness of the bark. Several of the trees killed with 2,4,5-T and 2,4-D esters at Dunbar Forest were cut in early November 1951, and pulpwood sticks peeled. Peeling was judged to be somewhat better than with green wood harvested at the same time, but was still quite difficult.

SUMMARY

Evidence obtained at the end of the first growing season indicates that:

Water solutions of 2,4-D amine salt and ester, in 6000 p.p.m. concentrations, applied as stem spray or to girdles, are not effective as a means of killing aspen.

Diesel oil solutions of 2,4-D amine salt, 2,4-D ester and 2,4,5-T ester in 6000 p.p.m. concentration, applied as stem spray to the girdles and to the frills, are effective to a variable degree. Of the three formulations, ester 2,4,5-T was the most effective, followed by 2,4-D ester. Amine salt gave inconsistent results.

Death produced by the esters is brought about slowly during the first growing season. Evidence obtained from previous experiments on red maple and aspen indicates that complete kill and some degree of bark peeling can be expected on all trees exhibiting evidence of injury at the close of the first season.

Stem spraying appears to be more effective than frill girdling, and at least as effective as complete girdling, followed by spraying.

No conclusive evidence has been obtained to indicate the relative importance of season or of weather conditions prevailing during the treatment, on the effectiveness of the treatment.

No bark loosening in the trees that died during the first growing season was apparent. Pulp sticks, cut in November 1951, from a few of such trees, peeled somewhat more easily than green wood harvested at the same time.

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TIMBER VALUES FROM MICHIGAN'S FORESTS

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THIS ARTICLE is a discussion of the role of Michigan's forests in the economic life of the state. It considers only timber products. Other benefits derived from the forest—wildlife, recreation, waterflow influences, and forage—have a huge value in the aggregate. These latter benefits are recognized, but satisfactory techniques for their appraisal have not yet been developed.

THE COURSE OF THE LUMBER INDUSTRY

Michigan's forests played a big role in the early economic development of the state. They offered a bountiful supply of timber for homes, barns, fences, fuel, and the host of other wood products needed by farmer and townsman. More than that, the forests provided the basis for a great lumber industry.

A rich resource was available for logging. The original forests covered about 97 percent of the state's 36.5 million acres. About 10 million acres were in pine types, and white pine was also abundant in the 9 million acres of northern hardwood forest. Some 8 million acres were in oak-hickory and bottomland hardwood. Another 8 million acres were in spruce-fir and coniferous swamp forests (3).

Pine was the mainstay of the big logging boom, although substantial volumes of maple, oak, and other hardwoods were also cut (6). The first steam sawmill went up in the Saginaw valley in 1834. Within 15 years, there were 558 sawmills in the state. Subsequent development of the lumber industry was so rapid that Saginaw alone raised its mill output from 92 million board feet in 1851 to more than a billion feet

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in 1882. Muskegon turned out about 800 million feet a year between 1873 and 1888 (9).

Michigan's peak year in lumber production came in 1889 when the state turned out nearly 5.5 billion feet of lumber (6). Thereafter, lumber production tapered off steadily (Fig. 1). It dropped below one billion board feet for the first time in 1917, and fell to a depression low of 111 million board feet in 1932. In World War II, despite the pressure to turn out a maximum amount of lumber, Michigan's industry produced an average of only about 500 million board feet a year, less than 10 percent of the 1889 output.

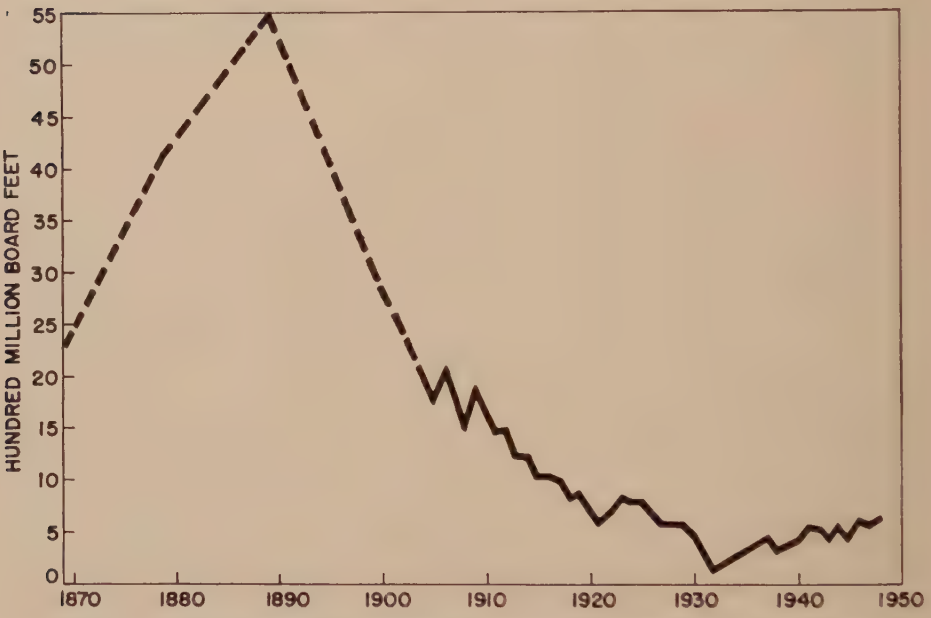

Fig. 1. Annual lumber production in Michigan, 1869-1948. (Source: U. S. Bur. Census. Only decennial data available before 1904.)

The reason for the tremendous drop in lumber output is clear. Demand did not fall off, but the forest resource was declining at a phenomenal rate. Few regions in the United States can point to such rapid and complete forest destruction as occurred in the pine forests of Michigan. It took only about 40 years to denude the great pine forests on some 10 million acres (2).

Hardwood forests in Michigan were not always cut over as completely as were the pine forests. Characteristically, the hardwoods have been cut in a high-grading process: a process of repeatedly creaming off the most desirable timber. High-grading often avoided complete destruction, but it did not save hardwood forests from considerable deterioration in species composition, volume, and quality.

THE CURRENT FORESTS

As a result of the long record of poor and destructive logging operations, the forests of the state are now in largely depleted condition. This is shown by a few highlights on Michigan's forest inventory.

Nineteen million acres—52 percent of the total land area—are still forested. The commercial forest[1] is estimated at 17.8 million acres (3). A fifth of the commercial forest area has less than 40 percent of the number of trees needed to fully stock the stands. Softwood species make up only 29 percent of the sawlog volume[2] of 19 billion board feet, 31 percent of the total growing stock[3] of 8.2 billion cubic feet (Table 1). The generally small size of timber is revealed by the fact that the cubic volume in cordwood trees is nearly 50 percent greater than that in sawlog trees (3).

The evidence points to further declines in the forest inventory, although declines are not occurring in all respects. Recent net growth in Michigan's forests has been estimated at 295 million cubic feet of total growing stock, including 519 million board feet of saw timber (7). Drain in 1948 was estimated at 283 million cubic feet and 759 million board feet (4). In sawlog sizes, where timber use is concentrated, drain is clearly in considerable excess of growth—among hardwoods, the excess is one-fifth; among softwoods, it is one-and-one-half times. Total growing stock, which includes the cordwood material too small for most timber use, appears to be approximately balanced, but the overall data are somewhat deceptive. The big deficit in softwood total growing stock is apparently balanced by an excess of hardwood growth. However, much of the hardwood gain is in relatively undesirable aspen, while the softwood loss occurs among more valuable species.

[1]Forest land capable of producing usable crops of wood within 100 years, and not withdrawn from timber use.

[2]Sawlog volume is the board-foot volume in live, merchantable softwoods 9.0 inches or larger in d.b.h. (diameter breast high), and hardwoods 11.0 inches or larger in d.b.h.

[3]Total growing stock is the cubic volume of sound, usable wood in sawlog portions of sawlog trees, and in upper stems of softwood sawlog trees and entire stems of cordwood trees to a minimum top diameter of 4 inches inside bark. Cordwood trees are well formed trees smaller than sawlog trees but at least 5 inches in d.b.h.

TABLE 1—Sawlog and total growing stock, by principal species, 1950

Species	Sawlog growing stock	Total growing stock
	(million bd.ft.)	*million cu.ft.)*
Softwoods:		
Hemlock	3,000	900
White pine	700	210
Balsam fir	600	420
Spruce	500	300
Cedar		300
Other	700	440
Total	5,500	2,570
Hardwoods:		
Sugar maple	5,100	1,630
Yellow birch	1,400	320
Oak	1,400	500
Elm	1,100	340
Aspen	1,000	1,700
Other	3,500	1,140
Total	13,500	5,630
All species	19,000	8,200

Source: Cunningham, R. N. Forest resources of the Lake States region, U.S.D.A. Forest Resource Report No. 1, Washington. 1950.

CURRENT OUTPUT OF PRODUCTS

Michigan's forests have been tremendously depleted. They may be likened to a factory which is turning out all its products in one wing because the main machinery is broken down. Yet, in spite of this, the record of production is impressive.

Sawlogs and fuel wood are the chief raw timber products (logs, bolts, and other round or split timber products) in terms of volume (Table 2). Together, they account for 202 million cubic feet, or 69 percent, of the total wood output. Pulpwood, which takes 18 percent of all timber, is in first place as a user of softwoods—41 percent of the total softwood output. Veneer logs take 5 percent of the total wood output; all other products take 8 percent.

TABLE 2—Volume of output by raw timber products and species group, 1948

Product	Softwood	Hardwood	All species
	(million cubic feet)		
Fuel wood*	13.0	91.0	104.0
Sawlogs	33.3	65.1	98.4
Pulpwood	37.7	15.1	52.8
Veneer logs	.....	14.3	14.3
Fence posts	4.3	3.8	8.1
Mine timbers	2.6	1.9	4.5
Chemical wood†	.....	4.3	4.3
Excelsior bolts	.....	3.6	3.6
All other	1.2	1.4	2.6
Total	92.1	200.5	292.6

Source: Horn, A. G. Commodity drain from forests of the Lake States, 1948, Lake States For. Exp. Sta., Station Paper No. 20, St. Paul, Minn. 1950.
*Does not include 19.5 million cubic feet of slabs.
†Does not include 1.3 million cubic feet of slabs.

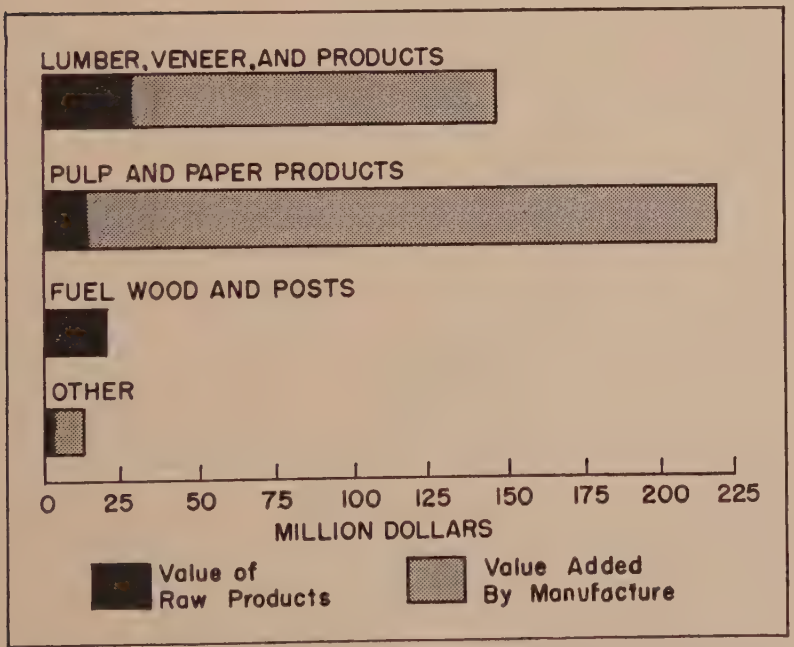

Fig. 2. Value of raw timber products in Michigan and value added by manufacture, 1948.

VALUE OF PRODUCTS

Michigan's output of raw timber products in 1948 was worth $65.7 million. Further manufacture within the state added $334.9 million in value. One group of products—pulp and paper—accounts for only a fifth of the value of raw products but nearly two-thirds of the value added by manufacture (Fig. 2).

Timber manufactures are carried to a fairly well advanced degree. This is made plain by the high ratio of value added by manufacture to value of raw timber. In pulp and paper products, the ratio is more than 15 to 1; in lumber, veneer, and products, the ratio is 4 to 1. By way of comparison, the comparable ratios for 12 southern states are about 5 to 1 and 2 to 1 (5).

Yet it should also be noted that, despite the high level to which its timber manufactures are generally carried, Michigan exports to neighboring states far more raw timber than it imports. In sawlogs, the net export is limited to 3 percent of total production, but in pulpwood the net export is more than a third of total production, and in veneer logs, more than four-tenths (4).

INCOME FROM TIMBER PRODUCTS

Not all the value of timber products can be credited as money income in the state. Some products, including most fuel wood and fence posts, are not sold for cash; and part of the total value is contributed by trades and services in the form of rent, taxes, insurance, etc., and cannot be considered as coming mainly from timber.

Allowing for those factors, the 1948 money income to the people of Michigan which can be attributed directly to timber products is calculated to have been $317 million. By way of comparison, this figure is about twice the income that can be attributed to the production of livestock and the manufacture of livestock products in the state. It is about two-thirds greater than the money income that can be attributed to dairying and the manufacture of dairy products in the state.

EMPLOYMENT IN TIMBER—PRODUCTS INDUSTRIES

How many workers find employment in forest industry cannot be estimated with accuracy, since much of the employment is part-time. Woods workers, in particular, are commonly farm workers who supple-

ment their farm income with seasonal woods labor. But in terms of full employment (fifty 40-hour weeks a year), Michigan's forest industry provides an estimated 70,600 man-years of employment—22,400 in cutting products in the woods and hauling them to mills; and 48,200 in manufacture (Table 3).

TABLE 3—Employment in timber-products industries, 1948

Type of industry	Woods	Mill	Total
		(man-years)	
Lumber and lumber products	4,900	19,600	24,500
Pulp and paper products	4,000	23,200	27,200
Fuel wood and posts	10,500	.....	10,500
Miscellaneous timber products	3,000	5,400	8,400
Total	22,400	48,200	70,600

INCOME ON THE FARM

Michigan's farms play a big role in the state's timber economy. This follows from the extent of farm woodlands in the state—3.7 out of a total of 17.8 million acres of commercial forest in the state. Experience indicates that farm woodlands usually are cut over more heavily and frequently than other forest properties. It may, therefore, be safely assumed that more than a fifth of the income from timber products in the state has its origin in timber taken from farm woodlands.

Income directly received by farmers is more limited. According to the Census, the value of forest products sold on farms in 1949 was $3.0 million. In view of the large role of Michigan's farms in the timber economy, this figure may appear unexpectedly low. One reason is that, in contrast to the sale of other farm crops, timber is usually sold as standing trees. The money received is a net return for a product that has involved no labor or direct cost on the part of the farmer. If the farmer customarily harvested and sold his timber crop like his regular farm crops, the value of his timber sales in 1949 would have been about $10 million instead of $3 million.

The farmer's chief returns from his timber are not in the form of money income. Fuel wood and posts are the principal products of farm woodlands, and usually these products are not sold. They are used on the farm. If they could not be obtained on the farm, they, or

adequate substitutes, would have to be purchased on the market. Their value—calculated to be $21 million in 1948—represents a substantial item in the farm economy. Similarly, a considerable volume of sawlogs is custom-sawed into lumber for use on the farm; hence it does not appear as money income. An estimated 80 million board feet of logs was custom-sawed in 1948, returning to farmers lumber worth at least $4 million more than it cost to have the logs sawed.

The timber values obtained by Michigan's farmers—$3 million in sales, $21 million in fuel wood and posts, $4 million in custom-sawed lumber—total $28 million. Some off-season farm labor is involved in obtaining these values, particularly in turning out fuel wood and posts, but very little cash cost is involved. Thus, the $28 million a year represents largely a net value return from farm woodlands. It amounts to about $7.50 per acre.

POTENTIAL INCOME

The foregoing review of the contribution of timber products to the economic life of Michigan must be weighed against the productivity of the forest resource. Michigan's forests have been heavily depleted. Yet they are currently yielding close to 300 million cubic feet of raw timber products a year; they provide about 70,000 man-years of employment; and they account for well over $300 million of income a year to the people of the state.

The data available on the forest situation indicate that some declines in timber inventory are still in progress. If these declines should continue long, they would result in a falling off in income and employment. However, there is nothing inevitable about further decline in the forest resources. Well managed stands on average sites are growing much more timber than the usual run of stands are currently growing—about twice as much in total growing stock, and three or four times as much in sawlog volume (1, 10).

A large increase in the timber yields of Michigan's forests cannot be achieved quickly or easily. There are many social and economic obstacles to instituting forest management on the many thousands of independently owned forest properties. There are economic problems which forest industry confronts in adapting its utilization of raw timber so as to aid in the improvement of the forest resources. There is also the physical obstacle of time—even under good management, it takes years to raise a depleted forest to productive condition.

Nevertheless, these problems are not all insoluble. Sufficient progress has been made by public landowners, individual landowners, and individual forest-products firms to indicate that timber yields can be vastly increased.

The question is sometimes raised: If forest productivity is increased substantially over the state, can we count on good markets for the increased timber yields? In answer, it needs to be pointed out that some increase in productivity is needed merely to assure the continued existence of Michigan's current forest industry. Morever, the demand for timber products in the state and region is greater than the local forest industry is able to supply. Lake States forests currently supply less than half of the sawlog products consumed in the region and about two-thirds of the total cubic volume of wood used (3). The rest must be imported from other regions despite the large cost of transporting heavy and bulky timber products over long distances. If more raw timber were available in Michigan, it would be only reasonable to conclude that the current demand for timber products would result in expansion of forest industry in the state.

How much additional timber should Michigan attempt to grow? This is a most difficult question to answer since it involves the many uncertainties of long-range forecasting. One answer is suggested by the recent U. S. Forest Service estimate of a long-range growth goal for the nation (8). This goal, calculated to produce the amount of timber that a prosperous nation might use if the supply were sufficient to keep forest products of suitable kind and quality available at reasonable prices, has been estimated at 20 billion cubic feet a year, including 72 billion board feet of sawlog volume. Michigan's share of the national growth goal—based on acreage of commercial forest land, potential rate of growth in the principal forest types, local accessibility of timber, ease of management, and location with respect to consuming markets—is calculated to be 405 million cubic feet annually, including 1,100 million board feet of sawlog volume.

The growth goal calculated for Michigan calls for more than a doubling of saw-timber growth and a one-third increase in growth of total growing stock. The improvements in management and utilization that would bring growth and drain into balance at this point would insure a great expansion in the income and employment dependent on Michigan's timber resources.

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DAMPING-OFF IN THE FOREST TREE NURSERY AND ITS CONTROL[1]

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DAMPING-OFF OF SEEDLINGS is a disease problem which confronts every grower of plants. Damping-off is of special importance when seedlings are grown closely together and in great numbers as is done whenever transplanting of the seedlings is practiced. This applies to the growing of forest and shade trees.

As for herbaceous plants, such as flowers and vegetables, the disinfection of the soil in flats by steaming or by application of fungicides to the soil surface has proved quite satisfactory in reducing losses by this disease. For the forest tree nurseryman who has large areas of outdoor seed beds with a dense population of seedlings, losses often run very high, and suitable control measures are difficult to manipulate.

These studies were begun as the result of the establishment of a forest tree nursery at Michigan State College on an area which had been cropped and pastured for many years. A very high incidence of damping-off occurred with the first sowing of seed.

CAUSE OF DAMPING-OFF AND SYMPTOMS

This disease is caused by several fungi which live and grow in the soil. For the most part they belong to the genera Pythium, Phytophthora, Fusarium and Rhizoctonia. Some or all of them are usually present in the nursery. These fungi are capable of feeding on the humus materials in the soil without the presence of living plant roots or stems. However, if seedling plants are present, they will attack and rot the succulent living tissues of the stem and roots. The typical

[1]Contribution from the Department of Botany and Plant Pathology, Michigan State College, No. 52-4.

[2]The writer is indebted to Ira Bull, Superintendent of Michigan State College Forest Nursery for his valued cooperation in these studies and for furnishing conifer seed and labor for the tests conducted in the nursery. The writer is also indebted to James Hodge, State Conservation Department, for a part of the red pine seed used.

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condition from which the name "damping-off" is derived, is the invasion and killing of the seedling stem tissues, near or at the soil surface. The infected tissues are rotted, and the seedling drops over and lies on the soil surface. Since the incidence of this disease is greater during periods of wet weather, the descriptive name "damping-off" is very appropriate.

Within a few weeks, after the seedlings emerge, the stem tissues become stronger and more rigid, and plants are less susceptible to rotting of the above-ground parts. However, the roots may be killed and rotted by these fungi. This phase of the disease is recognized as root rot.

These described forms of injury by parasitic soil-inhabiting fungi are known as post-emergence damping-off. The same organisms very often attack the young seedling as soon as it starts to germinate and before it emerges above the soil surface. Pre-emergence damping-off is usually not recognized as such, and the reduced number of emerging seedlings is attributed to poor viability and germinibility of the seed.

In some instances, such as with the Rhizoctonia fungi, the roots may be attacked after the stems become rigid and not subject to invasion. This is true of conifer seedlings whose roots may be rotted, with resultant death of the plants even into the second year of growth.

CONDITIONS FAVORING THE DISEASE

The more humus material present in the soil, the more favorable it is for the fungi as more food is available. Hence, muck soils are not suitable for seedbeds. On the other hand, sand usually supports few fungi and is often useful as cover for the seedbed. The large water-holding capacity of a soil high in humus is also a factor favorable for the development of damping-off, while sand affords good drainage. Probably the best medium for the seedbed is a mixture of sand and loam.

The acidity of the seedbed bears some relation to the fungi which will be present in it. An acid soil favors the development of Rhizoctonia, while a neutral or alkaline soil favors Pythium (4). In general, it is considered that a soil which is quite acid favors growth of conifer seedlings while inhibiting most of the damping-off fungi (2).

The various species of fungi causing damping-off have different requirements for their growth. For example, Rhizoctonia grows best in drier soils and at high soil temperatures, while Pythium grows best

in wet soils and at low temperatures (4). The variability of growth habits of these fungi makes the problem of control difficult. One species of fungus may be predominant in the soil one year, while another species may predominate in another year. These features account for the good control one season with a given fungicide and poor or no control in other years with the same fungicide.

CONTROL OF DAMPING-OFF

From the discussion of the factors favoring this disease, it is obvious that the first control measure is to provide a well drained seedbed and avoid over-crowding and over-watering.

The problem of combatting the damping-off fungi themselves necessitates soil sterilization to destroy all organisms present or the use of a fungicide specific for damping-off fungi.

Various means of sterilizing the soil are available. One of the best soil sterilization methods is steaming. However, it is not possible from an economic standpoint to treat large areas.

The use of fungicidal chemicals has been practiced for many years. These are sprinkled or dusted on the surface of the soil, either at the time of sowing or at intervals until the seedlings are a month to 6 weeks old. Some chemicals are mixed into the soil before the seed is sown. The practice of dusting tree seeds has been tried but with indifferent success, although the method is very satisfactory for the prevention of damping-off in vegetable and flower seedlings.

Sulfuric acid has been used for years in the treatment of conifer tree seed beds. In sandy soils low in humus content, it has been effective in preventing damping-off. Formaldehyde has been used with success on small areas of seedbeds. Aluminum sulfate, iron sulfate, acetic acid and similar chemicals applied primarily to increase the acidity of the soil, have reduced the incidence of damping-off markedly in many instances (1).

This paper reports the results of tests of various fungicides in the control of damping-off of conifer seedlings. The trials were conducted both in the nursery and in the greenhouse over a 3-year period. Fungicides have been applied as seed treatments, soil treatments before planting, and soil sprinkle treatments after planting. The materials tested are listed in Table 1.

TABLE 1—Fungicidal chemicals tested

Trade name	Fungicidal chemical	Manufacturer*
Arasan	Tetramethyl thiuram disulfide	E. I. duPont Company
Tersan	Tetramethyl thiuram disulfide (wettable)	E. I. duPont Company
Fermate	Ferric dimethyl dithiocarbamate	E. I. duPont Company
Ceresan M	Ethyl mercury p-toluene sulfonanilide	E. I. duPont Company
Ceresan NI	Ethyl mercury phosphate	E. I. duPont Company
1155—HH	Ethyl mercury phosphate + potassium iodide	E. I. duPont Company
Manzate	Manganese ethylene bisdithiocarbamate	E. I. duPont Company
Semesan	Hydroxymercurichlorophenol	E. I. duPont Company
Bioquin 1	Copper 8 quinolinolate	Monsanto Chemical Co.
Crag 658	Copper zinc chromate	Carbide & Carbon Chem. Corp.
224	Experimental fungicide	Carbide & Carbon Chem. Corp.
531	Experimental fungicide	Carbide & Carbon Chem. Corp.
640	Experimental fungicide	Carbide & Carbon Chem. Corp.
5400	Experimental fungicide	Carbide & Carbon Chem. Corp.
Phygon	2-3 dichloro napthoquinone	U. S. Rubber Company
Spergon	Tetrachloro parabenzoquinone	U. S. Rubber Company
Agrox	Phenyl mercury urea	Chipman Chem. Company
Vancide 51	Sodium dimethyl dithio carbamate+ sodium 2-mercaptobenzothiozate	R. T. Vanderbilt Co.
Cuprocide	Copper oxide	Rohm & Haas Company
Dithane Z78	Zinc ethylene bisdithiocarbamate	Rohm & Haas Company
Cop-o-zinc	Tribasic copper sulfate+zinc sulfate	Tennessee Corp.
Orthocide	N-trichloro methylthio tetrahydrothalimide	Standard Oil Co.
Acti-dione	Cyclo-heximide	Upjohn Company
Puraturf 177	Phenyl amino cadmium dilactate	Gallowhur Chem. Corp.

*The author wishes to thank the manufacturers listed for the materials they furnished for these tests.

SEED TREATMENTS

Various chemicals in the form of dusts or seed soaks were applied to red pine seed. Lots of 400 seed were used for each greenhouse test. Dusts were applied by shaking them with the seed in a glass jar. When the seeds were well coated, excess dust was screened off and seeds were planted in rows in flats of soil obtained from the forest nursery. This soil tested pH 5.6 and contained an abundance of damping-off fungi as was evident from the high incidence of damping-off (63 to 98 percent) in the untreated control plantings. Rhizoctonia and Fusarium were isolated many times from these diseased seedlings and Pythium on several occasions. Artificial inoculation of the soil was not practiced.

Vancide 51 was applied undiluted as a seed soak for 5 minutes, the seed being dried before planting. Acti-dione was used in water at

1, 10 and 100 p.p.m. as a seed soak for a 2-hour period. Seeds were then dried before planting.

In the greenhouse, seedbeds were watered daily or oftener when necessary to keep the soil moist at all times. Greenhouse temperatures were kept at 70° F. except during summer. A cloth shade 6 feet above the soil surface was employed during the months of May and June to reduce the temperature and avoid heat injury to seedlings.

Counts of emergence and damping-off were made at 2-day intervals for a period of about 2 months.

One seed dusting trial was conducted in the forest nursery in beds 4 by 16½ feet containing 8 rows, 6 inches apart. Two rows each of Scotch pine, red pine, Douglas fir and Norway spruce were planted in each bed. A different seed treatment was used in each bed. Each treatment was replicated twice. Seed was dusted as described above and was planted by a mechanical seeder at the rate of 3.6 ounces per bed.

In this test a minimum of irrigation was applied as is consistent with usual nursery practice. Counts were made at weekly intervals over a 6 weeks' period. Wooden counting-frames, 1 by 4 feet, were pegged down across the rows, two for each bed so that four series of

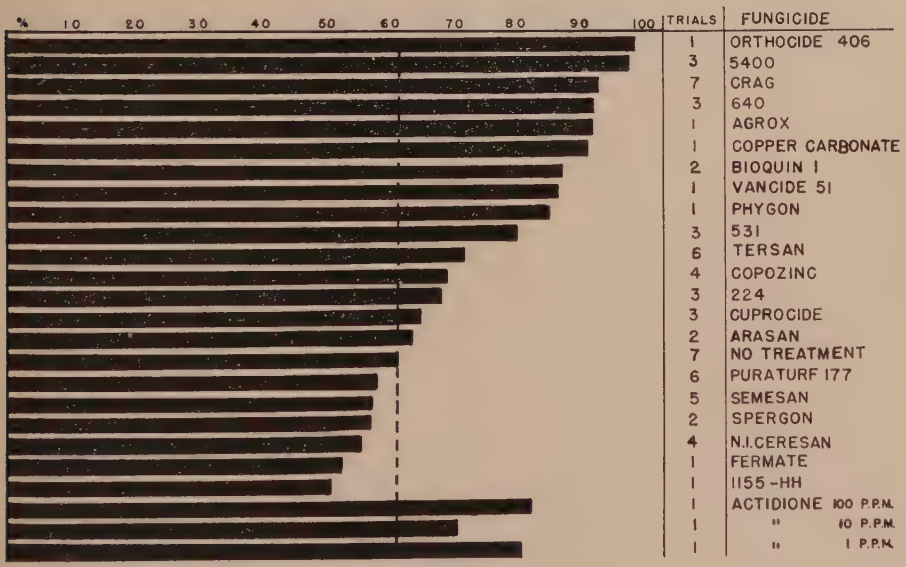

Fig. 1. Seed treatments.

counts were made for each treatment. Results from the four conifer species used are combined in these records.

Percentage of emergence was calculated on the basis of germination tests of the various seed lots used. Percentage of damping-off represents post-emergence damping-off and was calculated from emergence and damping-off counts. Data from the field test and six greenhouse trials were averaged and are graphically shown in Figs. 1 and 2.

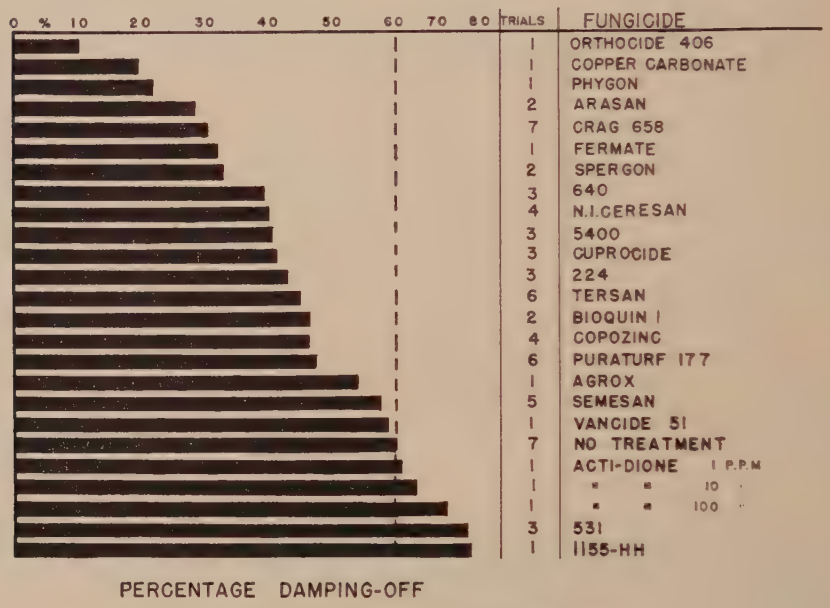

Fig. 2. Seed treatments.

SOIL TREATMENTS

Two methods of applying fungicides to the soil were tested. These were the thorough mixing of the chemical into the soil several days prior to sowing seed and the application of the chemical in water after seeding.

APPLICATION OF FUNGICIDES TO SOIL PRIOR TO SEEDING

For the greenhouse tests, an amount of soil sufficient to cover a foot square area, 3½ inches deep, was placed in a rotating drum with baffles. To this was added the calculated amount of fungicide for the desired rate per acre. The drum was closed and rotated 39 times or until thorough mixing resulted. The treated soil was then placed in a flat, labelled and left at least 3 days without watering before seeds

were planted. Four rows of 100 red pine seed each were planted per soil treatment. Watering and greenhouse temperatures were maintained as previously described, and counts were made as before.

For the tests in the nursery beds, the fungicide was evenly sifted onto the soil surface and the soil was mixed to a depth of 5 inches with a rototiller. Sowing of seed was delayed for 3 days. In the 1950 field test the same four conifer species were planted as described for the dust treatment; the seedbeds and counts followed the same plan. In the 1951 field test red pine seeds were sowed. New seedbeds were used, but the plan and methods were the same as before.

The data from the two field tests and three greenhouse trials were analyzed in the same manner as were those of the seed treatments and are shown in Figs. 3 and 4.

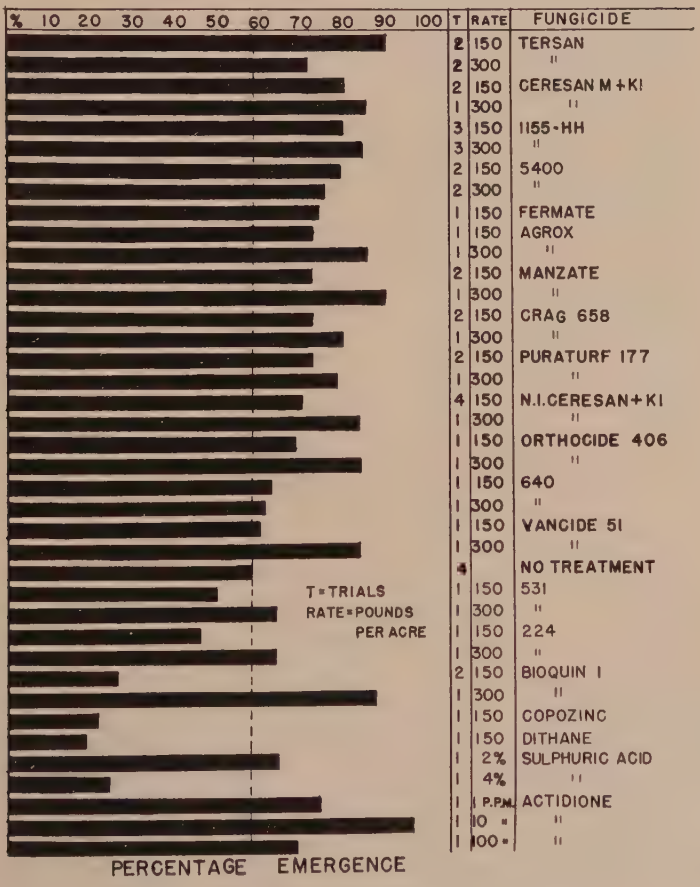

Fig. 3. Soil treatments before seeding.

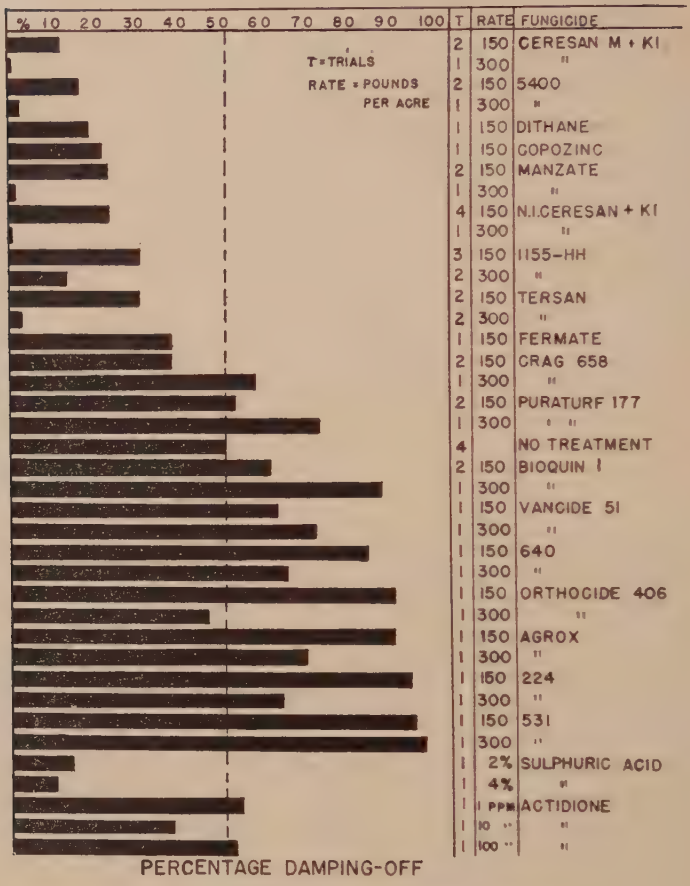

Fig. 4. Soil treatments before seeding.

APPLICATION OF FUNGICIDES TO SOIL AFTER SEEDING

Seedbeds of forest nursery soil were prepared in flats in the greenhouse and planted with red pine seed at the rate of 100 seeds per 14-inch row. There were four rows in each half flat separated by a wooden divider in the center of the flat. The chemicals were weighed at the rate of 10 pounds per acre and each was placed in 1 pint of water which was then applied with a bulb sprinkler to a half flat just seeded. The percentage of emergence was increased over that of the untreated controls by all treatments as follows: Semesan—1 percent, Tersan—16 percent, Puraturf 177—27 percent and Crag 658—22 percent. Percentage of damping-off, however, was reduced below the untreated control by only one treatment, Puraturf 177—3 percent.

It appeared that a heavier dosage at a later time might be more beneficial. Accordingly, the experiment was repeated, using the fungicides at the rate of 200 pounds per acre and applying the treatment 16 days after seeding or just before emergence. All treatments increased the percentage of emergence above untreated controls as follows: Semesan—10 percent, Tersan—50 percent, Puraturf 177—22 percent, Crag 658—41 percent, N. I. Ceresan—30 percent. Only Crag 658 and Tersan reduced the percentage of damping-off below the untreated controls, 32 percent and 15 percent, respectively.

In a later experiment, four different rates of application (10, 20, 150 and 300 pounds per acre) were tested, and treatments were applied in three parts at one-week intervals, beginning one week after sowing date. Three applications (one-third of the dose at each application) at one-week intervals gave more satisfactory disease control than when all of the dosage was used at a single application. Neither the 10- nor the 20-pound-per-acre rate of the materials tested (Crag 658, Tersan, Agrox, Orthocide 406, 5400 and Semesan) resulted in satisfactory control, although all increased the percentage of emergence and decreased that of damping-off as observed in the untreated controls. At the 150-pound-per-acre rate, all materials tested gave good

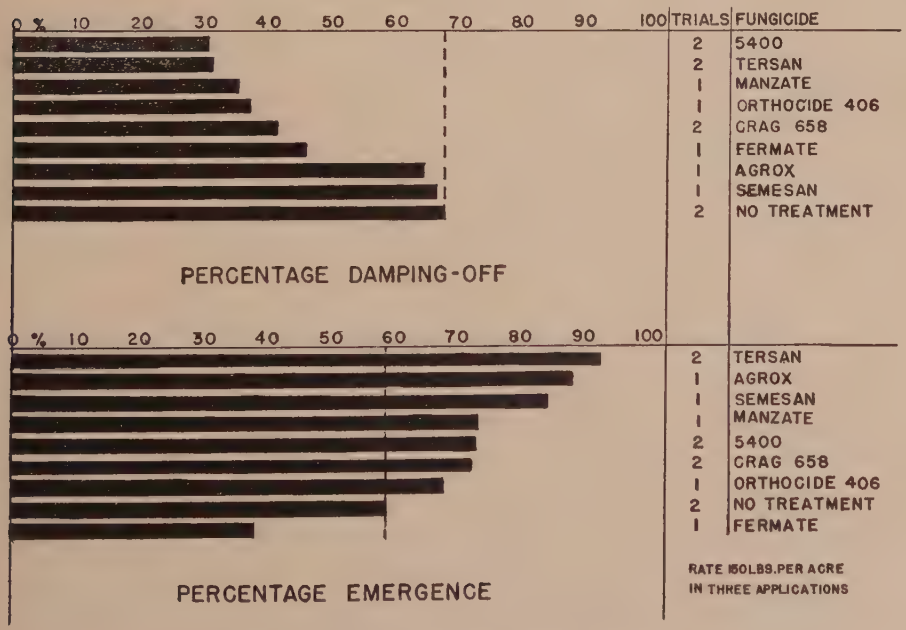

Fig. 5. Soil treatments after seeding.

damping-off control and emergence. While the 300-pound rate resulted in somewhat better control, the results were not enough better to warrant the doubled expense of the treatment. The data at the 150-pound-per-acre rate are averaged with results from a similar test in the nursery and are presented in the graph in Fig. 5.

DISCUSSION OF RESULTS

Incidence of damping-off was always greater in the greenhouse than in the nursery trials. Emergence also was always better in the greenhouse. Higher moisture content of the soil and higher temperatures probably account for these effects.

As previous experience of other research had already indicated (3), results were variable with repeated tests of the same fungicide. Some treatments which increased the percentage of emergence considerably were unsatisfactory in control of post-emergence damping-off and conversely.

Some fungicides tested actually increased the percentage of damping-off above that naturally occurring in the untreated controls. This may be due to an unnoticeable but slightly injurious effect of the chemical on the seedling, rendering it more susceptible to damping-off, or these fungicides may not be specific for the damping-off fungi, but may destroy other competing soil organisms so that conditions are actually made more favorable for the damping-off fungi.

Of the dust treatments tested, Phygon alone produced definite injury of the seedlings. Some fungicides, notably Semesan, Tersan, and Puraturf 177, did not adhere well to the seed and, consequently, effected poor damping-off control.

In seven trials, the use of Crag 658 as a seed dust treatment resulted in averages of 92.9 percent for emergence and 31 percent for damping-off. Orthocide 406 and Copper Carbonate in one trial each also gave excellent results. Experimental fungicides 5400 and 640 in three trials each were good with respect to emergence but less satisfactory for damping-off control. Tests with Crag 658 were extensive enough to warrant its recommendation for trial as a dust treatment of red pine. None of the seed soak treatments were satisfactory.

The soil sprinkle treatments after seeding indicate that fungicides at the rate of 150 pounds per acre in three applications at one-week intervals offer possibilities of good results both as to emergence and control of damping-off. Of the materials tested, Tersan produced

excellent results in two trials, while 5400 and Manzate were both good. Single applications tried and other rates of application were not so satisfactory as 150 pounds per acre in three applications of 50 pounds each.

At the 150-pound-per-acre rate, Ceresan M plus potassium iodide gave best control, with an average of 12 percent damping-off where fungicides were mixed into the soil prior to seeding. Damping-off percentages of 30 percent or lower were obtained with: Experimental fungicide 5400, Copozinc, Manzate, New Improved Ceresan plus potassium iodide, and Tersan in the order given. Emergence was very good with all of these compounds.

New Improved Ceresan plus potassium iodide is the same material as 1155-HH (ethyl mercury iodide) and was prepared by mixing 32 parts New Improved Ceresan with one part by weight of finely ground potassium iodide crystals in a ball mill. Ceresan M plus potassium iodide were mixed in the same proportions.

Because of their volatile nature these fungicides are dangerous to handle. Care must be exercised not to inhale the vapor or get the dust on the skin.

Sulfuric acid 2 percent (235 milliliters per square foot) in one trial in the greenhouse reduced damping-off to 15 percent but emergence was very poor. Sulfuric acid placed very low in comparison with several other materials when used in greenhouse tests in the same soil.

Acti-dione, an antibiotic compound, in one trial at 1, 10, and 100 p.p.m. by weight of soil when applied prior to sowing of the seed reduced damping-off below the average untreated control at 10 p.p.m. Emergence was very high at this concentration.

Although 300-pounds-per-acre amounts of most of the fungicides tested decreased damping-off more and increased emergence more than 150 pounds per acre, the improvement was not great enough to warrant the increased cost of this rate of application. The use of such high rates in the experimental tests is of value in determining possible chemical injury to seedlings and in learning if the reduction of damping-off may be increased proportionately above the 150-pound rate.

CONCLUSIONS

Twenty-five fungicides were tested for control of damping-off, and at least six had definite value. Three methods of application were

tested: seed treatments and soil treatments before and after sowing. In seven trials, Crag 658 was successful in damping-off control when used as a seed dust. When mixed with the soil at the rate of 150 pounds per acre before seeding, Tersan, Experimental fungicide 5400, New Improved Ceresan and Ceresan M plus potassium iodide, and Manzate showed considerable promise. Tersan as a sprinkle treatment, at 50 pounds per acre in three applications at weekly intervals after seeding, resulted in good damping-off control.

These treatments are suggested for trial on a small scale only and may not be successful under different conditions.

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THE EFFECT OF SEVERAL SOIL TREATMENTS ON MUMMY BERRY DISEASE OF BLUEBERRIES IN MICHIGAN[1]

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DEPARTMENT OF BOTANY AND PLANT PATHOLOGY

MUMMY BERRY, a disease caused by the fungus *Monilinia Vaccinii-corymbosi* (5), is becoming widely distributed in cultivated fields of the highbush blueberry in southwestern Michigan.

The disease is first noticeable on certain succulent new shoots that wilt, turn brown and die. The fungus is dormant within berries infected the previous season which have laid on the ground all winter. Early in the spring, the fungus becomes active, forming little mushrooms on the mummied berries. These mushrooms contain spores that shoot into the air and are carried upward by air currents, some of them landing on the new shoots and causing infections. In turn, the blighted shoots become covered with the mold spores which are carried to blossoms and young fruits during wet or rainy conditions. The infected fruit is tan or cream, instead of a normal green, and becomes hard and worthless. There is considerable direct loss, depending on the number of berries infected and further indirect loss as these spoiled berries make picking and sorting more difficult.

It has been observed that the fungus does not overwinter in cankers or blighted shoots in its life cycle (5). The primary inoculum consists of ascospores discharged from apothecia (small mushroom-like fruiting bodies) found on fallen berries in the spring when the blueberry plants are breaking dormancy. Primary infection is concerned with new shoot growth. The blighted shoots furnish secondary inoculum which infects the blossoms. If all primary infection could be controlled, there would be no secondary inoculum. Therefore, a control program based on the eradication of the primary inoculum in the spring is indicated.

[1]Contribution 52-3 Department of Botany and Plant Pathology.

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HISTORICAL SURVEY

Early investigations on this disease attempted the use of protectant fungicide applications. Bailey *et al.* (1) found that two applications of a 5-3-50 bordeaux mixture applied at the beginning and end of bloom appeared to be effective. Later studies in Maine (9) showed that a sanitary measure of sweeping or raking the mummied berries from the ground disturbed the growth of apothecia and helped reduce the incidence of disease. Also the data (9) indicated that a dust of 25-percent Monohydrated Copper Sulfate and 75-percent hydrated lime proved better than bordeaux, lime-sulfur, Oxo-bordeaux, copper cyanamid and copper carbonate if applied when about 80-percent of the blossoms have fallen and again 10 to 14 days later.

Recent experiments by Bailey and Sproston (2) and Bailey (3) indicated that Ferbam plus a sticker offered excellent possibilities for controlling mummy berry. The investigators concluded that the first application should be applied while the apothecia are maturing and should be followed by two cover sprays about 12 days apart.

Working with peach brown rot, caused by a related fungus with similar apothecial fruiting bodies, Huber and Bauer (6) reported using a dust formulation of calcium cyanamid for the destruction of apothecia. When this material was applied to the soil surface at the rate of 220 pounds per acre at the beginning of apothecial production, it destroyed the apothecia and prevented development of others. Darrow *et al.* (4) suggested, without presenting data, that calcium cyanamid dust applied at a 150-pound rate per acre seems to render blueberry mummies incapable of producing apothecial structures.

Experimental work by Johnston (7) in Michigan showed satisfactory results from early and thorough cultivation, using a three-bottom vineyard plow for coverage of mummied berries. Also hoeing between plants immediately after plowing reduced infection 50 percent. In 1949, without presenting details, Johnston (8) reported that a combination of diesel oil and Dow General Weed Killer gave good control of the disease. It is apparent from the foregoing investigations that control of mummy berry is possible. Prevention of primary infection by the eradication of the apothecia shows promise for the most economical control.

EXPERIMENTS IN 1951

The plantation where the experimental plots were located was checked for apothecial development on April 24, 30 and again on May

8. On May 8, the fruiting bodies of the organism were present in great abundance over the plantation floor and at this time the materials were applied. The buds on the Jersey and other mid- to late-season ripening varieties were very swollen, with some of the bud scales splitting. On the Adams variety, however, there were from 2 to 3 inches of green leaf tissue already showing.

Every spring the floor of this particular plantation is in a soft and springy condition which prohibits the use of cultivation and heavy spray machinery. Thus, a light model duster with two discharge flues was mounted on a wooden stone-boat which was pulled by a Caterpillar tractor. An oil-treated, finely powdered form of calcium cyanamid, called Aero,[2] was applied at the rate of 150 to 200 pounds per acre. The high rate of dust application was used to effect good coverage of the plant crowns and soil surfaces under the bushes. Krenite-26[3] (sodium salt of dinitro ortho cresol) and Premerge[4] (alkanolamine salt of dinitro-o-sec-butylphenol)were applied to wet thoroughly the ground area beneath each bush. A knapsack sprayer was used in the application of these last two materials.

Figure 1 shows the size and location of each plot used in these trials. The data were obtained in the following manner: A specific number of randomized bushes in each plot were picked completely free of infected berries and counted prior to actual harvest. In the check and the dusted plots the samples were obtained only from the center rows since the outside rows were probably contaminated with dust which drifted from adjacent plots.

Perceptible apothecial destruction was noted within 10 minutes after treatment in the calcium cyanamid dust plots, whereas no apparent deterioration was found in the dinitro plots. However, further examination of the apothecia from the dinitro sprayed plots disclosed plasmolysis (complete shrinking) of the ascospores. Tables 1 and 2 record the results obtained.

The undusted plot had 10 times more infection than the dusted plot indicating that calcium cyanamid was capable of reducing the incidence of disease. Further field observations in the dusted plots disclosed that Rubel, Rancocas, and Stanley, all mid- to late-season varieties, had an average of fewer than 6 infected berries per bush. The Adams, an early ripening variety had 160 to 187 infected berries per bush. Because of the scattered interplanting of these varieties,

[2]A proprietary formulation of calcium cyanamid of the American Cyanamid Co.
[3]A proprietary dinitro product of the E. I. Du Pont de Nemours Co.
[4]A proprietary dinitro product of the Dow Chemical Co.

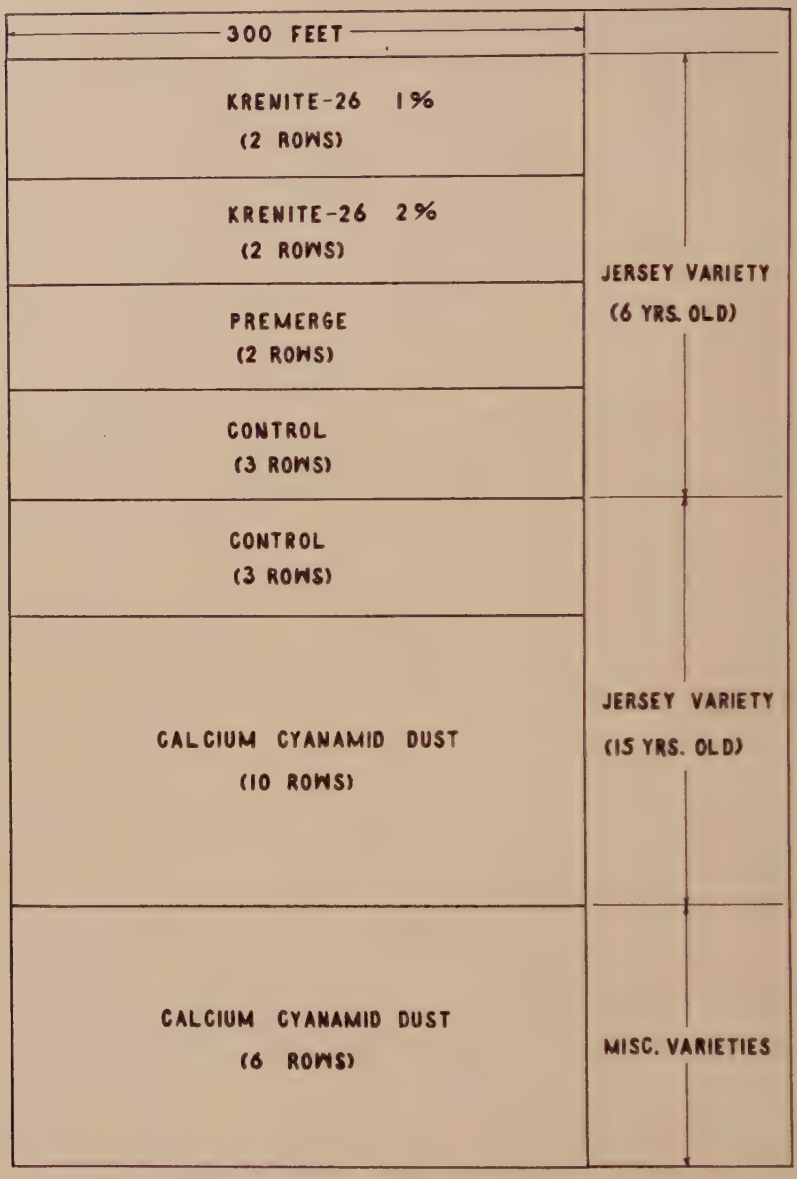

Fig. 1. Plan of mummy berry control experiment.

no controls were established and thus the data could not be confidently evaluated.

This plot consisted primarily of young plants that had not reached full fruit production. However, there was enough fruit to allow significantly comparative data as recorded in Table 2. The higher concen-

TABLE 1—The effect of calcium cyanamid dust on mummy berry of a 15-year-old planting of the Jersey Variety

Treatment	Number of bushes counted	Total number of infected berries	Number of infected berries per bush
Dusted.....	40	129	3.22
None.....	15	467	31.13

TABLE 2—The effect of two dinitro materials on mummy berry of a 6-year-old planting of the Jersey variety

Treatment	Dosage per 100 gallons	Number of bushes counted	Total number of infected berries	Number of infected berries per bush
Premerge.....	1½ qt. (approx.)	36	63	1.75
Krenite—26.....	1 gallon.....	36	84	2.33
Krenite—26.....	2 gallons.....	36	41	1.14
None.....	.....	15	173	11.53

trations of Krenite-26 appeared to give the greatest reduction of infection. From a practical standpoint, it would appear that either Krenite-26 or Premerge would control this disease.

No appreciable difference in the control of grasses and perennial broadleaf weeds was noted in any of the plots. The vegetative cover was not adversely affected by the chemicals used in these trials.

DISCUSSION

Four mid-season to late ripening varieties showed better control of mummy berry than Adams, an early ripening variety. As the Adams variety was already well sprouted, it was evident that some spore discharge had occurred before the eradicant fungicides were applied, and that the Adams was the only variety with susceptible tissue exposed at that time. It is probable that an earlier treatment would have prevented much of the infection on the Adams variety.

Although no injury resulted to bush or fruit in these trials, experience with other crops indicates the possibility that calcium cyanamid may cause serious injury under certain conditions. Then too, the con-

tinued use of calcium cyanamid may contribute to an unfavorable increase in soil alkalinity. These two considerations with regard to calcium cyanamid can be resolved only with further experimentation.

The three materials tested definitely reduced the amount of infection and increased the yield of marketable fruit. One season's trial, however, is not enough to evaluate fully all of the possibilities and disadvantages of any new control program. Further experiments and growers' experience are necessary before definite recommendations can be made.

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THE CHEMICAL CHARACTERISTICS AND THE EFFECT OF CALCIUM CARBONATE ON THE MANGANESE STATUS OF FIVE ACID ORGANIC SOILS

By J. C. SHICKLUNA[1] *and J. F. DAVIS*
DEPARTMENT OF SOIL SCIENCE

INCLUDED in Michigan's five million acres of organic soils are large areas intensely acid in character (pH 4.3 and below). The natural vegetation in many of these areas consists primarily of shrubs (leatherleaf, *Chamaedaphne calyculata,* and swamp blueberry, *Vaccinium myrtilloides*), and because of the extremely acid character of the soil, root systems of many trees are limited, resulting in some degree of simplification in subsequent clearing operations. In many instances these acid bogs are favorably located with respect to markets, nearness to improved roads and established drainage outlets. Because of their acid character, however, their development for agricultural purposes is an extremely hazardous undertaking.

The importance of an adequate supply of calcium in organic soils has long been recognized as essential for optimum crop yields. However, specific information is limited, regarding the rates of application of calcium required to bring about optimum conditions in acid organic soils.

It is important to recognize not only the beneficial effects of calcium, applied in the form of lime (calcium carbonate) in optimum amounts, but also possible detrimental effects associated with overliming.

Soil reaction (pH) is generally considered as a practical measure of the lime needs of an organic soil. It has been observed, however, that crops growing on organic soils with similar soil reactions vary in the degree to which they respond to lime applications. In extreme

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cases fair crops of onions have been produced on soils with a low pH, whereas the crop failed on other soils with the same pH. Soil reaction, therefore, does not always seem to be the best measure of lime requirement of organic soils.

While liming is a recommended soil management practice, excessive applications should be avoided lest certain micro-nutrient deficiencies, especially manganese and boron, be induced.

The following study was designed to investigate some factors associated with variation in the results obtained from liming organic soils.

PROCEDURE

Five virgin acid organic soils were obtained from four Michigan counties during the fall of 1950. The counties represented were Livingston, Ingham, Clinton, and Lapeer. The samples were taken to a depth of 12 inches.

The soils were partially dried and screened through a 4-mesh sieve. After the moisture content had reached what seemed to be optimum for the growth of plants, moisture was determined by drying at 115° C., and pH was determined by the glass electrode method.

The soils were placed in one-gallon glazed jars. All received a basic treatment equivalent, on an acre basis, to 2,000 pounds of 3-9-18 and 100 pounds of copper sulfate. Copper deficiency is common on acid organic soils.

The experimental treatments consisted of varying applications of calcium carbonate ranging, on an acre basis, from 0 to 12 tons, in increments of two tons. Each treatment was replicated three times. Thus, 7 treatments made a total of 21 pots for each soil. The lime was mixed thoroughly with the soil.

Onions were seeded at a depth of ¾ inch on January 19, 1951. The variety was Brigham's Yellow Globe. The seed had been treated with "Arasan." Plants were thinned to 4 per pot. Moisture was maintained by periodically bringing the pots up to weight with distilled water. The harvest was made on June 21. Records were made of air-dry weights of tops and bulbs.

The original soils were analyzed for the following exchangeable cations: magnesium (2)[2], calcium, potassium, sodium, iron (7), manganese (6) and hydrogen. Total analyses were made for iron and aluminum (4). In addition, the following properties were determined:

[2]Numbers in parentheses refer to literature cited.

pH value, total exchange capacity (5), exchangeable bases (1), and percent base saturation. The lime requirement for each soil was determined by Woodruff's method (9).

Exchangeable and easily reducible manganese and pH were determined on the soils after treatment (6) with calcium carbonate and following the harvesting of the onions.

Total manganese determinations (8) were made on oven dried tissue from the tops and the bulbs of the onions.

EXPERIMENTAL RESULTS

TABLE 1—Some chemical characteristics of five acid organic soils

Soil	pH	Milliequivalents per 100 grams of air dry soil			Percent base saturation
		Exchangeable hydrogen	Total exchange capacity	Exchangeable bases	
1.....	3.6	65.2	81.8	16.6	20.3
2.....	3.7	62.5	80.4	17.9	22.3
3.....	4.0	62.4	84.7	22.3	26.3
4.....	4.3	40.8	74.5	33.6	45.2
5.....	5.0	12.9	71.6	58.7	82.0

As shown by the data in Table 1, the five soils a) differed quite widely in their content of exchangeable hydrogen, b) possessed a high exchange capacity, and c) contained a large amount of replaceable bases. As the pH value increased, the amount of exchangeable bases and percent base saturation increased, and the exchangeable hydrogen content decreased.

*TABLE 2—Exchangeable bases, organic matter, and ash contents of five acid organic soils**

Soil	Percent		Milliequivalents per 100 grams of air dry soil					
	Organic matter	Ash	Ca	Mg	K	Na	Mn	Fe
1.....	91.0	9.0	13.6	1.2	0.3	1.4	0.009	0.015
2.....	93.2	6.8	14.3	1.2	0.4	1.2	0.004	0.010
3.....	90.9	9.1	15.4	2.1	0.4	1.5	0.005	0.017
4.....	91.6	8.4	25.9	2.5	0.3	1.5	0.009	0.009
5.....	87.6	12.4	44.9	2.6	1.3	2.2	0.013	0.011

*Organic matter determined by ignition at 500-600° C.

As shown by the data reported in Table 2, calcium was found to be the predominant cation in each of the soils. A comparison of the data in Table 2 with that in Table 1 shows that a positive correlation exists for percentage base saturation and total exchangeable calcium. The other bases occurred in order of decreasing amounts as follows: magnesium, sodium, potassium, iron, and manganese.

The organic matter contents varied from 93.2 percent in soil 2 to 87.6 percent in soil 5. As would be expected, the ash percentages in the five soils varied in exactly the reverse order, from 6.8 to 12.4.

TABLE 3—Percent total iron, aluminum and manganese in five organic soils

Soil	Percent		
	Fe	Al	Mn
1	0.22	0.32	0.0056
2	0.16	0.26	0.0025
3	0.19	0.28	0.0027
4	0.30	0.38	0.0044
5	0.43	4.70	0.0113

As shown in Table 3, the order of magnitude in which the above three elements occurred in the soils were 1) aluminum, 2) iron, and 3) manganese. The percentages of the three elements did not vary greatly among the first four soils, but they were all high in soil No. 5, the one which was highest in exchangeable bases and lowest in exchangeable hydrogen. Aluminum was particularly high in this soil.

TABLE 4—Lime requirement of five acid soils

Soil	1	2	3	4	5
Lime requirement, tons*	13.1	13.1	12.5	11.2	7.5
Original pH	3.6	3.7	4.0	4.3	5.0

*Per acre 500,000 pounds of soil.

Lime requirement is defined as the amount of lime required to bring the soil to pH 7.0. As shown by the data presented in Table 4, there was a general decrease in the lime requirement of the five soils as the pH value increased from 3.6 in soil No. 1 to 5.0 in soil No. 5.

A comparison of Tables 4 and 6 shows that a good agreement existed for soils 2, 3, and 4 between the amount of lime required to raise the soil pH to 7.0, as calculated by Woodruff's lime requirement method, and that determined by actual liming. However, this situation did not hold for soils 1 and 5.

Attention should be called to the wide variation in buffer capacity of these organic soils. Buffer capacity is the degree of resistance that a soil has to changes in pH value. Even though soils 1 and 2, in their natural state, have approximately the same pH, the addition of lime at the rate of 12 tons per acre changed the pH from 3.6 to 5.6 for soil 1 and from 3.6 to 7.0 for soil 2.

TABLE 5—The manganese status of five acid soils

Soil	pH	Form of manganese			
		Exchangeable	Easily reducible	Inert	Total*
		p.p.m.	p.p.m.	p.p.m.	p.p.m.
1	3.6	25.0	12.5	18.7	56.2
2	3.7	3.5	3.7	17.8	25.0
3	4.0	3.7	2.5	20.3	26.5
4	4.3	8.7	2.5	32.8	44.0
5	5.0	15.0	8.7	88.8	112.5

*The sum of the three forms, exchangeable, easily reducible, and inert.

The manganous-manganic relationship of the five soils is shown in Table 5. The exchangeable manganese varied considerably in the five soils. For soils 2, 3, 4, and 5 the percentage of exchangeable manganese of the total did not vary appreciably. The percentages were 14, 14, 20, and 13 respectively. For soil 1, however, 44 percent of the manganese was in the available form. This was associated with both the difference in the amounts of total manganese that each soil possessed and also with the difference in soil reaction. The high pH values favored the oxidation of the available manganese to the unavailable manganic form.

The amount of easily reducible manganese for each of the five soils was relatively small, but was highest in soils 1 and 5 which also contained the largest amounts of total manganese.

TABLE 6—The effect of calcium carbonate applied to five soils in the greenhouse on the yield of onion bulbs, soil reaction, and content of exchangeable and easily reducible manganese

Tons of $CaCO_3$ per acre	Mean yield* (grams per pot)					Exchangeable manganese, p.p.m.					Easily reducible manganese, p.p.m.					pH Value				
	Soil					Soil					Soil					Soil				
	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5	1	2	3	4	5
0	0.33	0.19	166	212	203	25.0	3.5	3.7	8.7	15.0	12.5	3.7	2.5	2.5	8.7	3.6	3.6	4.1	4.4	4.9
2	145	175	201	217	180	17.5	5.0	5.0	6.2	13.7	6.2	3.5	2.5	2.5	33.7	4.1	4.2	4.8	5.0	5.2
4	149	172	213	202	192	15.0	3.7	3.7	3.7	1.2	5.0	2.5	8.7	1.2	25.0	4.5	5.0	5.3	5.5	6.0
6	164	141	196	202	190	10.0	2.5	1.2	2.5	3.7	5.0	2.5	3.7	5.0	13.7	4.8	5.0	5.8	6.1	6.2
8	168	108	151	187	140	5.0	1.2	0.0	1.2	1.2	12.5	2.5	3.7	6.2	20.0	5.0	6.0	6.4	6.6	6.6
10	151	46	103	161	172	0.0	0.0	0.0	0.0	2.5	8.7	2.5	3.7	1.2	.....	5.3	7.0	6.9	7.0	6.9
12	146	37	79	143	159	0.0	0.0	0.0	0.0	0.0	6.2	2.5	1.2	1.2	15.0	5.6	7.0	7.1	7.2	7.0
Least significant difference																				
1% level	33.1	37.6	35.8	0.0	0.0															
5% level	23.6	26.8	25.5	55.2	31.0															

*Averages of three replications.

There was a relatively small amount of manganese fixed as inert MnO_2 in soil 1, owing possibly to its intensely acid character. However, the manganese fixation was considerably greater for soils 4 and 5. Apparently soil reaction is not the only factor in determining the amount of the various forms of soil manganese because with only 0.1 pH difference between soils 1 and 2, 70 percent of the manganese in soil 2 was inert as compared with 33 percent for soil 1.

As shown in Table 6, the exchangeable manganese decreased in the five soils with increasing calcium carbonate applications and pH. It has been stated by Sherman and Harmer (6) that in alkaline soil at least 3 p.p.m. of exchangeable manganese and 100 p.p.m. of easily reducible manganese must be present for satisfactory crop production. From these data it is observed that the exchangeable manganese becomes deficient (less than 3 p.p.m.) at pH values ranging from about 5.0 to 5.5. As the pH was raised beyond this range, exchangeable manganese fell off rapidly. At the neutral point the values had reached zero in all the soils. The content of easily reducible manganese was below 100 p.p.m. in all of the soils.

*TABLE 7—The effect of calcium carbonate on the total manganese in the tops and bulbs of onions**

Treatment, tons $CaCO_3$ per acre	Parts per million (oven-dry basis)									
	Soil 1		Soil 2		Soil 3		Soil 4		Soil 5	
	Tops	Bulbs	Tops	Bulbs	Tops	Bulbs	Tops	Bulbs	Tops	Bulbs
0	†	†	.....	.....	125	50	175	22	875	50
2	1,125	100	338	38	63	31	169	22	173	28
4	625	88	200	22	61	25	31	12	50	19
6	350	53	75	13	31	3	19	7	31	.....
8	225	38	25	9	19	6	13	7	25	16
10	94	28	75	13	19	6	13	4	22	13
12	44	25	22	3	13	6	13	6	25	13

*Dried for 48 hours at 80-85° C.
†Tissue analyzed for total iron, aluminum and manganese.

As shown by the data in Table 7, the total manganese content of the tops and bulbs decreased as the amount of calcium carbonate was increased. With the lower applications of lime the manganese in the tops and the bulbs was in the ratio of approximately 10:1. Where the lime applications were larger this ratio was considerably smaller. With the greatest applications of lime, where the pH had reached

about 7.0, the ratio was approximately 2:1 for those plants grown on soils 3, 4, and 5. In every instance the quantity of total manganese was greater in the leaves than in the bulbs.

A comparison of the data in Tables 5, 6 and 7 shows that with one exception (soil 2) the content of total manganese in the plant varied directly with that of exchangeable manganese in the soil. The correlation with total manganese in the soil was not so high.

Soil 5 was highest in content of total manganese. However, the onions harvested from soil 1, which contained half the amount of total manganese found in soil 5, had the greatest percentage of manganese in both tops and bulbs. The variation in the ratio between total and exchangeable manganese in the two soils is probably the result of the difference in pH of the two soils. Soil 5 had a higher pH value and had less exchangeable manganese available for plant use.

The higher amounts of manganese in the plant tissue from soil 2 which contained less total and exchangeable manganese than soil 4, is possibly due to the antagonistic effect of calcium since soil 4 contained nearly twice the amount of exchangeable calcium, or to the effect of calcium on the oxidation of the manganese.

TABLE 8—The effect of calcium carbonate on the yield and partial composition of onions grown on soil 1

Tons of $CaCO_3$ per acre	Iron, aluminum and manganese in plant tissue			Yield per pot, grams
	Fe, percent	Al, percent	Mn, percent	
0 (soil pH 3.6).....	.17	2.6	.04	0.33
2 (soil pH 4.1).....	.03	0.3	.12	145.00

As shown by the data in Table 8, onions grown on soil 1 contained more aluminum than iron or manganese both when grown with the addition of calcium carbonate and without it. However, the percentage of aluminum and iron was considerably less in the plant tissue of onions from soils to which calcium carbonate had been added; conversely, however, the percentage manganese increased in the plant tissue of onions from soils to which calcium carbonate was added.

The yield of onion bulbs increased with an increased amount of calcium carbonate and an increased pH value. As shown in Table 6, a high degree of significance between treatment yields was obtained

with soils 1, 2, and 3 and significance at the 5-percent level for soils 4 and 5. The yield on soil 1 was increased with increasing increments of lime up to the 8-ton treatment. Additional lime decreased the yields below that obtained from the 8-ton treatment. The exchangeable manganese content of soil 1 decreased consistently with each increasing increment of lime. The yield of onions on soils 2, 3, and 4 was increased with calcium carbonate additions of 2, 4, and 2 tons, respectively. In soils 2 and 3, the content of exchangeable manganese increased with the addition of 2 tons of calcium carbonate, and then became smaller with further additions of lime. With soil 4, as with soil 1, exchangeable manganese contents decreased consistently with increased applications of lime.

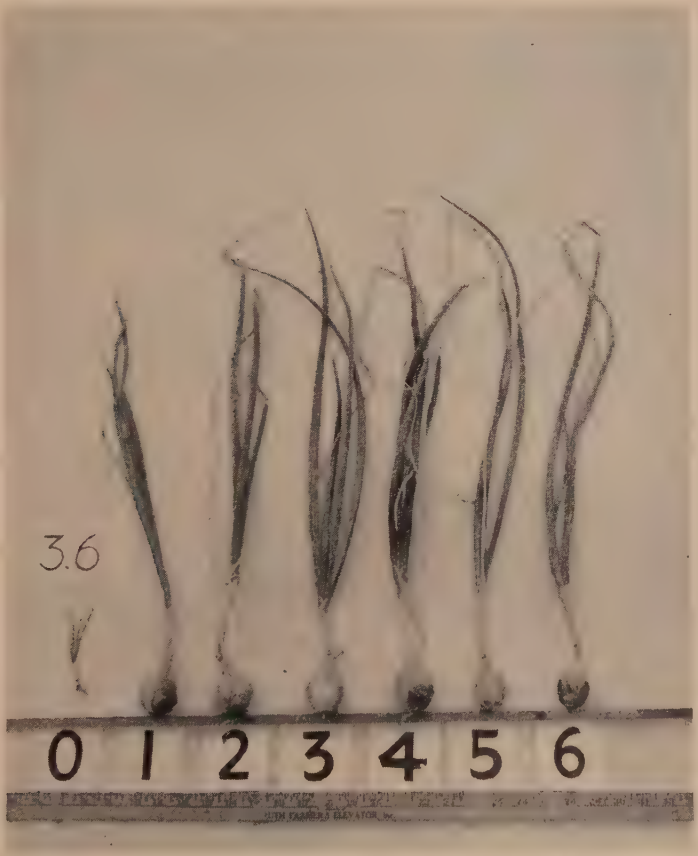

Fig. 1. The effect of calcium carbonate on the growth of onions grown on soil 1 having an original pH of 3.6. (0 = none, 1 = 2 tons, 2 = 4 tons, 3 = 6 tons, 4 = 8 tons, 5 = 10 tons, 6 = 12 tons.)

It is shown from these data that maximum yields on soils 1, 2, and 3 were obtained where the exchangeable manganese content of the soil was 5.0 or 3.7 p.p.m. The original pH values for the three soils, in order, were 3.6, 3.7, and 4.0, respectively. In soils 4 and 5, where the pH was 4.3 and 5.0, respectively, the p.p.m. of exchangeable man-

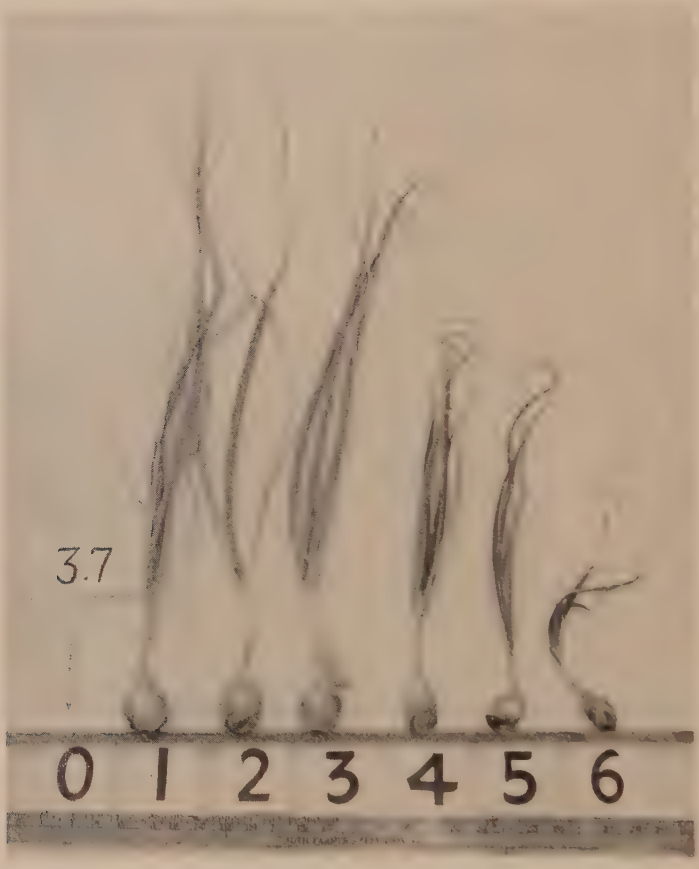

Fig. 2. The effect of calcium carbonate on the growth of onions grown on soil 2 having an original pH of 3.7. (0 = none, 1 = 2 tons, 2 = 4 tons, 3 = 6 tons, 4 = 8 tons, 5 = 10 tons, 6 = 12 tons.)

ganese were greater and maximum yields were obtained at 6.2 and 15.0 p.p.m., respectively. It is evident from these data that maximum yields on soils of an intensely acid character (pH 3.6 - 4.0) required less (fewer p.p.m.) exchangeable manganese than did soils less acid in reaction.

From these data, 4 to 5 p.p.m. of exchangeable manganese appeared to be optimum in intensely acid soils, while 6 to 14 p.pm. were necessary for maximum yields on soils with pH values of 4.3 or 5.0.

A different growth curve was obtained for each soil, as shown by Figs. 1 to 5. Calcium carbonate significantly affected the yields on all

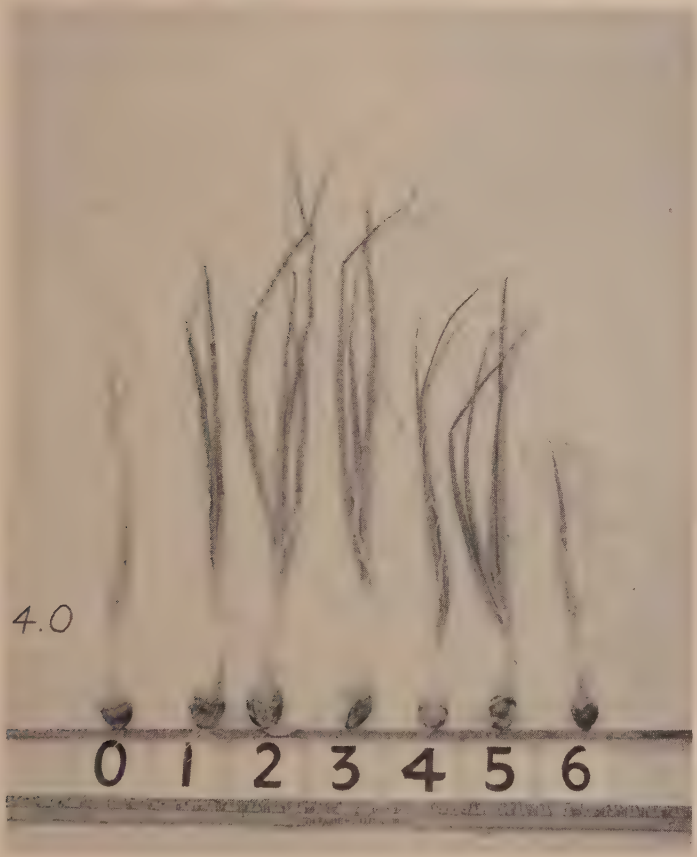

Fig. 3. The effect of calcium carbonate on the growth of onions grown on soil 3 having an original pH of 4.0. (0 = none, 1 = 2 tons, 2 = 4 tons, 3 = 6 tons, 4 = 8 tons, 5 = 10 tons, 6 = 12 tons.)

of the soils. The response occurred as decreased yields for soils 4 and 5 and as increased yields for soils 1 and 2. After the optimum lime application was reached in the first two soils, further increments resulted in consistently smaller response. Thus, the growth curve was up, then down. To a lesser extent the same may be stated about soil 3. As shown in Table 9, the highest yields were obtained between the

pH range of 4.2 to 5.3. From Table 7 it is seen that a marked decrease in the p.p.m. of manganese in the onion bulbs occurred as the soil pH approached neutrality. Definite manganese deficiency symptoms resulted. This was observed during the early stages of growth. The tips of the leaves developed a light yellow color and later died and in some cases fell off. As shown in Table 7, the onions grown where 6-, 8-, 10-, and 12-ton applications of calcium carbonate had been made contained very little manganese in their bulbs. The small amounts of manganese in the onion bulbs and the symptoms that occurred during their early and late stages of growth indicated that a deficiency of manganese was responsible for the lower yields obtained where the heavier lime treatments had been made.

Fig. 4. The effect of calcium carbonate on the growth of onions grown on soil 4 having an original pH of 4.3. (0 = none. 1 = 2 tons, 2 = 4 tons, 3 = 6 tons, 4 = 8 tons, 5 = 10 tons, 6 = 12 tons.)

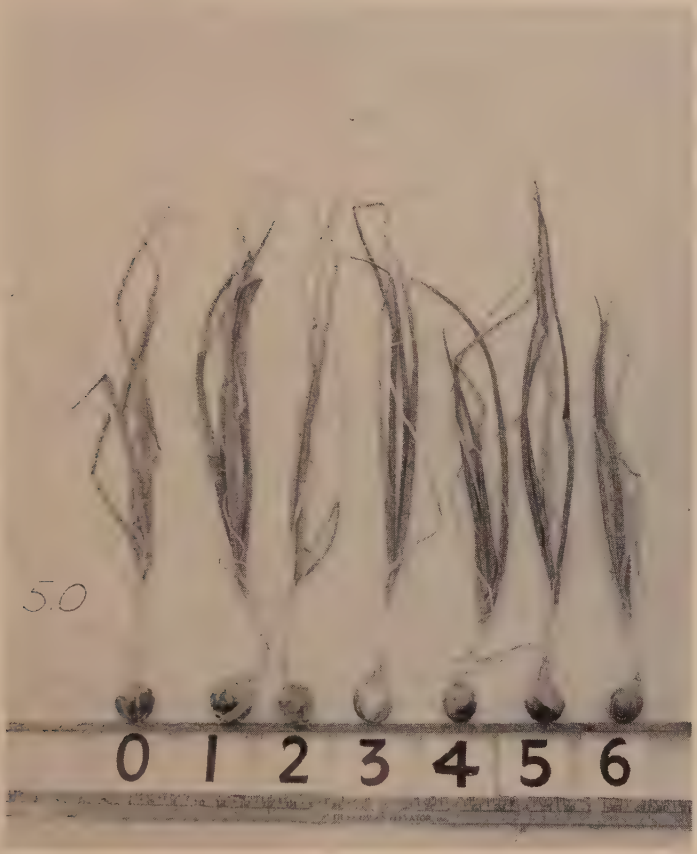

Fig. 5. The effect of calcium carbonate on the growth of onions grown on soil 5 having an original pH of 5.0. (0 = none, 1 = 2 tons, 2 = 4 tons, 3 = 6 tons, 4 = 8 tons, 5 = 10 tons, 6 = 12 tons.)

TABLE 9—The pH values at which the highest onion yields were obtained and the p.p.m. of manganese contained in the bulbs

Soil	pH	Tons of calcium carbonate required to raise soil reaction to indicated pH.	Total manganese in onion bulbs, p.p.m.
1.....	5.0	8	38
2.....	4.2*	2	38
3.....	5.3	4	25
4.....	5.0	2	22
5.....	4.9	0	50

*There was little difference in the yield resulting from the 2- and 4-ton calcium carbonate treatments.

DISCUSSION

As shown by the data, lime added to an acid organic soil may result either in an increase or a decrease in the yield of onions, depending on the soil and the amount of the lime added. The decrease in yield appears to be associated with the manganese status of the soil. Three forms of soil manganese are recognized: exchangeable, easily reducible, and inert forms. The exchangeable and easily reducible forms are considered available to plants, whereas the inert form is unavailable. For this reason the total amount of manganese in the soil is not a good criterion of the ability of any soil to provide sufficient manganese for a crop. When lime is added to a soil, manganese, through oxidation, may move from the available to the inert form. If a soil is overlimed an actual deficiency of manganese may be induced. The optimum amounts of the various forms of soil manganese apparently varies with different soils. Sherman and Harmer (6) considered that in any alkaline organic soil at least 3 p.p.m. of exchangeable manganese should be present for satisfactory crop production, and in order to maintain an adequate level of the exchangeable fraction this should be supplemented by at least 100 p.p.m. of easily reducible manganese. In acid soils the optimum level of exchangeable manganese can be much lower, with the amount depending largely on the degree of acidity.

The data reported in this paper show that onions without manganese deficiency symptoms can be grown on acid organic soils with a total manganese content less than 100 p.p.m. even when a considerable portion is in the inert form. Therefore, the pH of the soil appears to be a dominant factor in the manganese availability status of a soil. For example, maximum yields of onions were obtained with soils varying in pH from 4.2 to 5.3 and with lime additions ranging from 0 to 8 tons per acre. The amount of manganese in the onion bulbs varied from 22 to 50 p.p.m. From these data it is very evident that pH is not the only criterion associated with the lime requirement of an acid organic soil. With soils of very similar pH values the rate of application may vary as much as 2 to 8 tons per acre.

Soils of similar reaction also vary in their response to overliming; some soils require much less lime to induce manganese deficiency than do others. One of the reasons for the differences in behavior of soils is the amount of exchangeable calcium that is contained. This is illustrated by the data in Table 2. Soils 1, 2, and 3 contained 13.6,

14.3, and 15.4 milliequivalents, respectively, of calcium per 100 grams. Soil 4, with 25.9 milliequivalents of calcium, did not give a significant increase in yield of onions from lime as compared with soil 3, having a similar pH value. The latter soil gave a marked response to lime. Lime added to soil 5 resulted in a substantial decrease in crop yields.

Therefore, the exchangeable calcium content of a muck soil should be considered together with the pH in making a lime recommendation. The importance of this factor should not be overlooked because of the great danger in inducing manganese deficiency through over-liming.

One of the reasons why crops do not grow well on extremely acid acid soils is the soluble aluminum and iron which may be present in amounts sufficient to be toxic. One of the reasons for liming is to counteract these toxic conditions.

SUMMARY

Five acid organic soils ranging in pH from 3.6 to 5.0 were obtained from five locations in Michigan. The effect of varying rates of lime applications on these soils was studied under greenhouse conditions, using onions as the indicator crop. Rates of application of lime varied from nothing to 12 tons per acre.

The following properties of the soils were determined: pH, exchangeable hydrogen, total exchange capacity, exchangeable bases, percent base saturation, lime requirement, exchangeable manganese, easily reducible manganese and total manganese. The onion tops and bulbs were analyzed for their manganese content.

1. The five soils differed quite widely in content of exchangeable hydrogen, possessed a high adsorptive capacity for bases, and contained a large amount of replaceable bases. As the pH of the soils increased, their content of exchangeable bases and percentage base saturation increased, and the exchangeable hydrogen content decreased.

2. The percentage base saturation was found to be closely related to the calcium content of the soils.

3. Calcium was the predominant exchangeable cation.

4. In general, the cations appeared in the following order of decreasing amounts: calcium, magnesium, sodium, potassium, iron and manganese.

5. The organic matter content of the five soils varied from 93.2 to 87.6 percent, and their ash content varied in reverse order from 6.8 to 12.4 percent.

6. Good agreement between the results from the Woodruff lime requirement method and actual greenhouse results was obtained in only three of the five soils.

7. Considerable variation was found in the amount of lime required for the various soils for optimum growth of onions, without the use of supplemental manganese fertilizer. The amount of lime required had very little relationship to the pH of the soils. No significant positive response to lime applications was obtained with soil 4 which had an original pH value of 4.3 whereas soils 1, 2, and 3, with pH's varying from 3.6 to 4.0, gave a good response.

8. Manganese deficiency resulted from the application of too much lime on all of the soils. However, a different growth curve, representing the response to lime and also the result of over-liming, was obtained for each of the soils.

9. Highest yields of onions were obtained from soils having pH's varying between 4.2 and 5.3 and with lime additions ranging from 0 to 8 tons per acre. The total manganese content of these onion bulbs varied from 22 to 50 p.p.m.

10. With intensely acid soils (below pH 4.3) 4 to 5 p.p.m. of exchangeable manganese in the soil appeared optimum. For less acid conditions (pH 4.3 to 5.1), 6 to 14 p.p.m. of exchangeable manganese was found to be optimum under the conditions of this experiment.

11. From the data obtained, pH is not the only soil factor to be considered in making recommendations for the lime needs of an organic soil. In order to give more accurate recommendations, the exchangeable calcium content of the soil should also be considered.

12. If feasible, a determination of the amounts of the various forms of manganese contained in the soil would be of considerable value in making lime recommendations.

13. The lime applications used in this experiment are based on an acre 6 inches deep, and under field conditions it would be necessary to increase the incorporation of the lime to depths of 15 to 20 inches. For this reason the rates of application under greenhouse conditions are not necessarily the rates required for actual field applications.

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METHODS AND EQUIPMENT FOR HARVESTING LADINO CLOVER SEED

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THE INTEREST in ladino clover as a forage and seed crop is constantly increasing. In 1950 the production of seed was nearly 8 million pounds. The U. S. Department of Agriculture is anticipating an annual need of 12,384,000 pounds by 1955, and 14,855,000 pounds each year after 1960.

When cut for seed, the ladino vegetation is from 4 to 10 inches tall, with many of the seed heads bent over almost to the ground. Growth of green material is continuous and the seed, when ripe, shatters very easily. Those conditions make the harvesting of ladino clover seed difficult and inefficient when using the usual grass seed harvesting equipment.

Experimental work begun at Michigan State College in 1944 indicates that the vacuum-type harvester recovers more ladino seed than other methods. Four previous reports have been made on this method of harvesting white clover seed. Dexter and McKibben[1] in 1945 reported preliminary trials and made recommendations for rebuilding the equipment. Dexter and Sheldon[2] in 1947 described the enlarged machine. It was tractor mounted and was used successfully in harvesting about 100 acres of ladino seed during the summers of 1945 and 1946. The summer of 1947 was not favorable for the production of ladino seed and, as a result, the harvester was not extensively used that summer. Sheldon and Dexter[3] reported in 1948 on the harvesting of 1,485 pounds of ladino clover seed from a field of 12.1 acres in which the performance of the vacuum harvester was compared with that of a combine harvester. Combining from the swath recovered 60

[1]Dexter, S. T., and McKibben, E. G., "Vacuum-type Harvester for White Clover Seed," Mich. Agr. Exp. Sta. Quart. Bul. 27 (3): 294-297. 1945.
[2]Dexter, S. T., and Sheldon, W. H., "The Vacuum Harvester for Clover Seed," Mich. Agr. Exp. Sta. Quart. Bul. 29 (3): 331-336. 1947.
[3]Sheldon, W. H., and Dexter, S. T., "Harvesting Ladino Clover Seed with a Vacuum Harvester," Mich. Agr. Exp. Sta. Quart. Bul. 31 (2): 215-218.

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pounds of seed an acre, and from the windrow 100 pounds. Vacuum harvesting from the swath recovered 160 pounds of seed per acre. Hanna[4] reported in 1951 on: 1) Air velocity required to lift ladino clover seeds; 2) the design of a more efficient suction nozzle free of stagnant air pockets; 3) a comparison of several methods of harvesting ladino clover seed; 4) recommended procedures for harvesting ladino clover seed under different conditions of vegetative growth, weather, and sizes of fields; 5) suggestions for improving the design of a vacuum-type harvester for ladino clover seed.

Some of his data and conclusions are here summarized.

AIR NEEDED AND SUCTION NOZZLE DESIGN

The actual velocity of air required to support ladino clover seeds was found to be 512 feet per minute. In practice, a much higher velocity is needed. An average velocity of 1,200 to 1,500 feet per minute across the heel and toe openings of the suction nozzle of the machine in Fig. 1 was effective in lifting a small windrow of ladino

Fig. 1. A vacuum-type harvester for small windrows of Ladino clover.

[4]Hanna, G. B., *Development of Vacuum Harvesting Equipment for Small Legume Seeds,* Thesis for Degree of Ph.D., Michigan State College, 1951 (unpub.).

clover. This required a volume of from 2,400 to 3,000 cubic feet of air a minute for each foot of nozzle width. With the machine moving forward at a speed ranging from 1 to 4 miles an hour, there was very little difference in performance. At higher speeds more material was left on the ground, largely because of the difficulty of steering accurately enough to keep the 24-inch nozzle over a crooked windrow ranging in width up to about 20 inches.

Laboratory tests using an air velocity meter, pitot tube, and smoke indicated that the air movement through this design of suction nozzle was very turbulent, that there were no stagnant areas, and that the air was directed against the ground before entering the suction pipe.

HARVESTING METHODS COMPARED

Pan Method—A 4- by 5-foot pan was attached to the rear edge of a 5-foot cutter bar. Two men walked behind the pan to keep the cutter bar raked clean and to remove the clover from the pan, which was emptied every 50 to 60 feet onto pieces of sisal kraft paper. To cut one acre required three men with a tractor mower about 6 hours.

Vacuum Harvest from Windrow—A center-delivery windrow attachment was used with the 5-foot mower cutter bar. This eliminated the raking operation which would thresh out some of the seed and would loosen and place in the windrow small stones and other foreign matter which had been passed over by the cutter bar. The vacuum harvester shown in Fig. 1 was designed and built to pick up these windrows after they were thoroughly dry. The harvester blower discharged through a 12-inch pipe into a trailing wagon. The wagon was covered with a burlap top to let out the air but hold in the seed and chaff.

Vacuum Harvest from the Swath—This method utilized the same machine as for windrows, but it was not satisfactory without a rotary pickup device within the suction nozzle as previously reported by Dexter and McKibben.

Vacuum Harvest Direct from Cutter Bar—This method was abandoned. The clover became pasty after passing through the blower and was very difficult to dry mechanically with heated air.

Combining from Swath—A commercially made rotary pickup device with retracting fingers was used on a standard make of combine.

Combining from Windrow—The same combine and pickup device was used to harvest from swaths and windrows.

Sweeping the Field with Brush-type Vacuum Harvester After Removal of Vegetative Matter by Other Methods—This method was not satisfactory because of the wet weather which delayed the removal of vegetative matter until new growth was several inches tall.

Results from Four Harvesting Methods—Figure 2 shows a comparison of the amount of seed harvested by four methods—pan method, vacuum harvest from windrow, and combining from swath and windrow. The data presented represent an average of four plots of 1/50 acre for each harvesting method. The amount of ripe seed present in the field before harvest was estimated from count of ripe heads in random 2- by 2-foot areas. An average of the head counts in 11 such areas revealed 26 percent white heads (no mature seeds), 41 percent ripe heads standing, and 33 percent ripe heads bent to the ground.

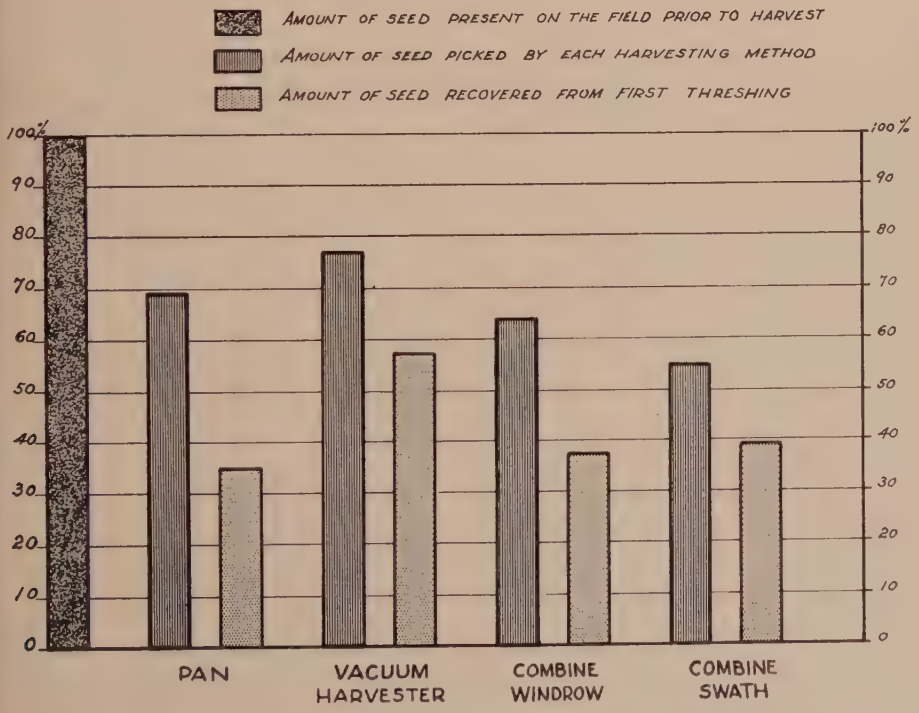

Fig. 2. A comparative analysis of the picking efficiencies and overall efficiencies of four harvesting methods.

The amount of seed "picked" was that picked up from the sisal kraft paper by hand, sucked up by the vacuum harvester, or picked up by the combine. The difference between the amount of seed picked and the amount of seed recovered from the first threshing represents seed passed through the threshing mechanism. A part of this was recovered in successive threshings. Experimental trials indicated that approximately 90 percent of the total amount of seed picked can be recovered by three threshings.

The higher overall efficiency of the vacuum harvester is partly due to the threshing of seed as the clover passes through the blower.

The most serious losses in harvesting ladino seed are: 1) weather hazards; 2) inefficient collection of vegetative material; 3) inefficient threshing. Of these, wet weather is the most serious because ladino clover is difficult to dry. It contains new growth, and a rain stimulates more new growth to come up through the undried material lying in the field.

RECOMMENDED PROCEDURES

When one compares the several harvesting methods, it is evident that no one method is best for all conditions. The pan method very definitely is limited to small acreages. It involves a lot of labor but not much extra equipment.

The combine is most suitable when the ladino clover is tall or mixed with other tall legumes or grasses, but is very inefficient if the ladino clover is less than 6 inches tall at cutting time.

The vacuum harvester outperforms any other method when the ladino clover is short and the weather is dry. Vacuum harvesting from the swath gets more seed than from the windrow, but requires a larger nozzle with a pickup device. This would cost more to build and would require more power for the operation of the larger blower. Placing the clover in a windrow reduces the amount of such material as dirt and stones that will be picked up by the vacuum harvester. A windrow, however, dries more slowly than a swath and if soaked by rain, a windrow will not dry out and the entire crop will be lost. The cost of a vacuum-type harvester in addition to a combine probably cannot be justified unless one has at least an average of 15 acres of ladino clover to harvest each year. Figure 3 shows the comparative gross income from different harvesting methods based on a) an assumed

yield of 200 pounds per acre and b) considering the overall efficiencies given in Fig. 2 and c) a price of $1.75 per pound of cleaned seed.

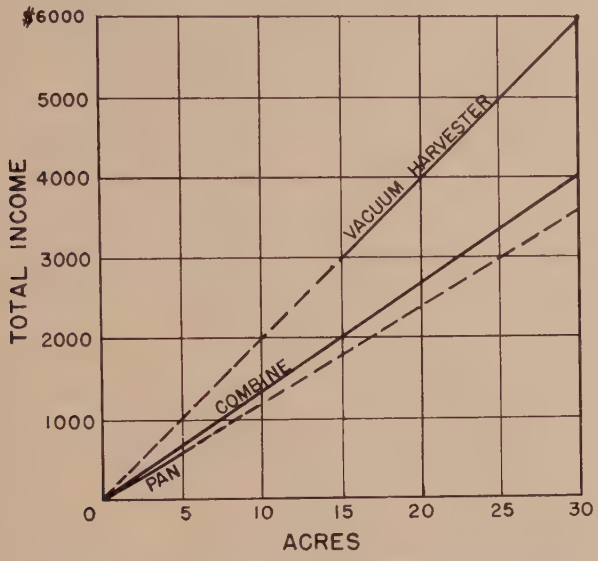

Fig. 3. Comparative gross income from different harvesting methods based on an assumed yield of 200 pounds of seed per acre and considering the overall efficiencies given in Fig. 2 and a price of $1.75 per pound of cleaned seed.

SUGGESTIONS ON VACUUM HARVESTER DESIGN

The following suggestions are based on the results of all the vacuum harvester research to date at Michigan State College. The authors believe that a trailing-type unit is preferable to one mounted on the tractor.

1. To harvest a full 5-foot swath, use a nozzle width of 5 feet with a retracting finger-type pickup within the suction nozzle.

2. Operate the pickup mechanically at 30 to 35 r.p.m. for each one mile per hour of forward speed and with the axis of the pickup rotor at an angle of about 70 degrees from the direction of machine travel.

3. Use a materials-handling blower with an opening 17 to 19 inches in diameter. An opening of this size is not likely to clog with large weeds. An air volume of 12,000 to 15,000 c.f.m. is needed, and the velocity of air entering the suction nozzle should be at least 1,000

feet per minute. A blower of this size and capacity will require 25 to 30 HP. and should be operated by an auxiliary engine.

4. Two or three 4-wheel wagons are needed so that harvesting will not have to wait for a wagon to be emptied. The bottom and sides of each wagon must be tight enough to hold the ladino seeds and the top covered with burlap to retain the seed and to allow the air to escape.

FEEDING RUNT PIGS

By J. A. HOEFER, R. W. LEUCKE and F. THORP, JR.[1]
DEPARTMENTS OF ANIMAL HUSBANDRY, AGRICULTURAL CHEMISTRY AND ANIMAL PATHOLOGY

METHOD OF FEEDING is very important in swine management. Undoubtedly many runts develop, but some pigs die and others make inefficient use of their feed because of poor feeding methods. Self-feeding is by far the most popular way of feeding growing-fattening pigs because experience has shown that this method of feeding results in faster gains on less feed with far less labor than hand-feeding. Likewise free-choice feeding, a method of feeding which allows the pig to select his own ingredients, has always been popular because it eliminates the need for mixing the various feeds and supplements used to make a complete ration. Free-choice feeding is based upon the idea that pigs will, when given a choice of a grain and various supplements, always balance their ration correctly. Since the choice of feed made by the pig appears to be influenced greatly by palatability it would appear that there may be many conditions under which the pig fed free-choice may actually be suffering from a nutrient deficiency because of poor feed selection. Palatability is not necessarily related to nutritive completeness; corn for example is extremely well liked but is also very deficient in a number of essential nutrients.

One of the important factors contributing to the development of runt pigs is faulty nutrition. Earlier work at this station by Luecke *et al.*[2] demonstrated the importance of protein and B vitamins in the nutrition of unthrifty pigs, particularly those having a nutritional type of enteritis. Catron and his associates[3] at the Iowa Experiment Station reported that the antibiotic aureomycin used with adequate B vitamins was far superior to skimmilk in stimulating growth in runt pigs. With the thought that many pigs may be runts because of their inability

[1]The authors are indebted to Chas. Pfizer & Co., Inc., Brooklyn, N. Y., for the terramycin, and to Merck & Co., Inc., Rahway, N. J., for the B vitamins used in this study.
[2]Luecke, R. W., F. Thorp, Jr., W. N. McMillen, H. W. Dunne and H. J. Stafseth, 1949. A study of B-vitamin deficiencies in pigs raised on farms. Mich. Agr. Exp. Sta. Tech. Bul. 211.
[3]Catron, Damon and Peter Cuff, 1951. Runt pigs can be saved. Iowa Farm Science 5: 119-122.

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or failure to select the right feeds when fed free-choice it was decided to make a comparison between a complete mixed ration and a free-choice ration of corn and a complete supplement.

EXPERIMENTAL

Eighteen typical runt pigs were used to form two uniform lots of 9 pigs each. These pigs averaged 8 to 10 weeks of age and ranged in weight from 12 to 21 pounds. All were scouring and showed the thin, emaciated, unthrifty appearance so characteristic of runt pigs. To eliminate the effect of parasites, all pigs were sprayed with lindane for lice and mange, and wormed with sodium fluoride before being started on experiment. The pigs were fed and housed in small, outside, paved lots.

One lot was self-fed a complete mixed ration, and the other lot was offered corn and a supplement free-choice in a divided compartment self-feeder. The supplement was complete for proteins, minerals and vitamins and was formulated so as to supply the same nutrients as the complete mixed ration. The antibiotic terramycin was added to both rations at the rate of 5 mg. per pound of complete ration and 15 mg. per pound of supplement. The composition of the experimental ration is given in Table 1.

TABLE 1—Composition of experimental rations

Ingredient	Complete Ration*	Free-choice
Corn, percent	72.5	.....
Soybean meal (solvent), percent	15.0	56.0
Meat scraps, percent	5.0	20.0
Alfalfa meal, percent	5.0	17.0
Limestone, percent	1.0	2.7
Dicalcium phosphate, percent	0.9	2.5
Iodized salt, percent	0.5	1.5
Trace mineral, percent	0.1	0.3
Riboflavin, gm./1000 lb.	2.0	6.0
Ca-pantothenate, gm./1000 lb.	4.0	12.0
Niacin, gm./100 lb.	6.0	18.0
B_{12} (Merck #622), mg./1000 lb.	6.0	18.0
Terramycin, gm./1000 lb.	5.0	15.0
Crude protein, percent	17.1	39.5

*Vitamin A and D concentrate added to supply the equivalent of 2000 I.U. of vitamin A and 250 I.U. of vitamin D per pound of complete feed and 6000 I.U. of vitamin A and 750 I.U. of vitamin D per pound of supplement.

RESULTS AND DISCUSSION

A study of the results summarized in Table 2 reveals that while there was little difference in the average rate of growth between the two groups of pigs there was a very significant difference in feed

TABLE 2—Results of runt pig feeding experiment (summer 1951) (9 pigs per lot—feeding period 8 weeks)

Comparison	Complete mixed ration	Free-choice corn supplement
Average initial weight, pounds	16.3	17.1
Initial range in weight, pounds	14–20	12–21
Average final weight, pounds	70.5	72.8
Final range in weight, pounds	55–86	13–97
Average daily gain, pound	.97	.99
Average daily ration, pounds	2.01	2.75
Corn	1.46	2.12
Supplement	.55	.63
Average total feed per pound gain, pounds	2.08	2.76

utilization. The pigs fed the complete mixed ration required only 2.08 pounds of feed per pound of gain whereas the free-choice-fed pigs needed 2.76 pounds of feed for each pound of gain, a difference of 23.9 percent in favor of the mixed ration.

The pigs fed free-choice ate 0.74 pound more feed per day and selected corn and supplement in such proportions so as to make a ration of 16-percent protein. This compares with the 17.1-percent protein content of the complete ration. In spite of selecting a ration a little lower in percentage of protein, the free-choice-fed pigs actually had a protein intake 0.10 pound higher than the pigs on the complete ration. However, when this protein intake is broken down as to origin it is interesting to note that 44 percent of the protein intake of the free-choice-fed pigs came from corn, whereas in the case of the pigs on the mixed ration, corn supplied only 37 percent of the protein. This difference in protein intake may be a partial explanation for the great difference in efficiency of feed utilization between these two lots of pigs since it is known that corn protein is of very poor quality.

The feed consumption figures obtained in this experiment would seem to indicate that palatability and not nutritive completeness is the major factor influencing the pigs' selection of feed and resulted

in this trial in the free-choice-fed group eating 45.2 percent more corn and only 14.5 percent more supplement than the group which had no choice. It was observed at the end of the experiment that the pigs in the free-choice lot showed far greater variation in size than the pigs on the mixed ration, which suggests that individual pigs differ in the way they select free-choice feeds. A pig may be unthrifty because of an inherently higher requirement for nutrients, and under a free-choice method of feeding this condition may be aggravated by the pig's inability to balance his ration correctly.

The very excellent gains and feed conversion records made by the runt pigs used in this experiment, particularly those fed the complete mixed ration, indicate that with proper nutrition a very high percentage of runt pigs can be made to grow into profitable hogs. It is necessary to fortify the ration with adequate B vitamins and an antibiotic to stimulate appetite and to reduce or eliminate the scouring which is typical of most runt pigs. In this experiment scouring stopped in both lots after one week on the fortified rations. Appetite stimulation is very important because observation indicates that many runts are semi-starved simply because of appetite failure. The complete mixed ration seems to give best results with unthrifty pigs because it insures an adequate balanced intake of nutrients with each bite of feed.

SUMMARY

Two groups of typical unthrifty runt pigs were used to study two methods of feeding. One group was self-fed a complete mixed ration; the other was self-fed, free-choice corn and a complete supplement. Both rations were formulated so as to supply adequate protein, minerals, vitamins and an antibiotic.

There was no difference in rate of gain, but the pigs on the complete mixed ration were 24 percent more efficient in converting feed to gain and were more uniform in appearance. All scouring stopped in both lots after one week on the fortified rations.

It is recommended that for runt pigs a highly fortified ration including supplementary B vitamin and antibiotic be formulated and fed as a complete mixed ration.

THE GROWTH-PROMOTING EFFECT ON PIGS OF A SURFACE-ACTIVE AGENT

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DEPARTMENTS OF AGRICULTURAL CHEMISTRY, ANIMAL HUSBANDRY AND ANIMAL PATHOLOGY

ELY[2] found that the inclusion of lauryl ethylene oxide condensate, a surface-active compound, stimulates the growth of chicks to a significant degree. The amount of surface-active compound used was 50 grams per 100 pounds of an all-vegetable-type broiler ration. Harris and Sherman[3] found that the inclusion of high levels of certain surface-active agents containing polyoxyethylene and sorbitan groups in a synthetic diet inhibited the growth of rats.

The surface-active agent used in the present trial was Ethomid C/15 (Armour and Company, Chicago, Ill.). The Ethomids are N-substituted fatty acid amides, the substituents being polyoxyethylene groups.

EXPERIMENTAL

The basal ration used in this trial was composed of corn, 78 percent; meat and bone scraps, 4 percent; solvent-processed soybean oil meal, 15 percent; limestone, 1.4 percent; dicalcium phosphate, 0.1 percent; iodized salt, 0.5 percent; and a trace mineral premix (Cal. Carb. Corp.), 0.1 percent. Vitamins A and D were added to the ration in amounts which supplied 2000 I.U. of vitamin A and 500 I.U. of vitamin D_2 per pound of feed. In addition, the ration was supplemented with B vitamins in the following amounts per pound of feed: niacin, 9 mg.; calcium pantothenate, 6 mg.; riboflavin, 2 mg.; and vitamin B_{12}, 3 μg. The crude protein content of the basal ration was 16.0 percent by analysis.

[1]The authors are indebted to Lederle Laboratories Division, American Cyanamid Co., Pearl River, N. Y., for the aureomycin and B vitamins, and to the Armour Laboratories, Chicago, Ill., for the Ethomid C/15 used in this study.

[2]Ely, C. M. Chick-growth stimulation produced by surfactants. Science 114: 523-524. 1951.

[3]Harris, R. S. and Sherman, H. Nutritional and pathological effects of sorbitan monolaurate, polyoxyethylene sorbitan monolaurate, polyoxyethylene monolaurate, and polyoxyethylene monostearate when fed to rats. Arch. Biochem. and Biophys. 34: 249-258. 1951.

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The pigs used in this experiment were of the Yorkshire breed and were approximately 8 weeks old at the start of the trial. For the duration of the experiment the animals were kept on concrete floors, bedded with straw and were self fed.

RESULTS

The growth response of the four experimental lots is shown in Table 1. The pigs (lot 2) given an addition of 0.1-percent Ethomid C/15 in their basal ration made a 35.8-percent increase in growth over

TABLE 1—Growth response of pigs fed the various experimental rations (Five animals in each lot on trials lasting 8 weeks)

Lot number	Supplement	Average starting weight	Average daily feed	Average daily gain	Feed/ gain
		lb.	lb.	lb.	lb./lb.
1	None	33.4	3.18	0.95	3.36
2	Ethomid C/15 @ 0.1%	33.6	4.07	1.29	3.15
3	Aureomycin @ 5 mg./lb.	33.0	3.88	1.28	3.05
4	Ethomid C/15 @ 0.1% plus Aureomycin @ 5 mg./lb.	33.0	4.16	1.19	3.49

the pigs (lot 1) which received no supplement. The growth response of the pigs fed aureomycin (lot 3) was not surprising since it has been demonstrated by many workers that this antibiotic stimulates the growth of swine to a marked degree. The pigs in lot 4 fed both the Ethomid C/15 and the aureomycin did not grow quite as well as either of lots 2 or 3. However, the growth response of the pigs in this lot was markedly greater than that of the pigs in the basal lot 1.

There seems to be no adequate explanation at the present time to account for the growth-promoting properties of Ethomid C 15. Whether this effect is due to the surface-active nature of the compound or to some other property remains to be determined.

JOURNAL ARTICLE ABSTRACTS

A Study of the Effects of Some Different Sods and Fertilizers on Sugar Beet Yields

Gregg, C. M., and Harrison, C. M.

Proc. Am. Soc. Sug. Beet. Tech. 1950: 306-310. 1950 (Journal Article 1140 from the Michigan Agricultural Experiment Station)

In a study of the effects of several grass sods on sugar beet yields, the workers found that orchard grass and bromegrass sods produced the best yields of beets, while timothy and sheep fescue sods gave the poorest yields.

Higher percentage stands of sugar beets resulted as the amount of 3-12-12 fertilizer applied was increased. Nitrogenous fertilizer alone resulted in very slight increases over that of the check. There was no correlation between organic matter content, aggregation or pore space of the soil and the yield of sugar beets. Penetrometer tests indicated that a soil which remained mellow for the first half of the growing season gave better yields than that which was more compact during this period.

Antibacterial Substances in Seed Plants Active Against Tubercle Bacillus. I. The antibacterial principles of Aloe vera, Linn. and Menispermum canadense, Linn.

Gottshall, R. Y., Jennings, J. C., Weller, L. E., Redemann, C. T., Lucas, E. H., and Sell, H. M.

Am. Rev. Tuberculosis 62(5):475-480. 1950 (Journal Article 1141 from the Michigan Agricultural Experiment Station)

An antibacterial principle present in *Aloe vera* which is active against the tubercle bacillus has been found to be the glycoside barbaloin. The antibacterial activity of extracts from *Menispermum canadense* is due to a mixture of alkaloids. The methods of isolation and some of the biological properties of these antibacterial substances are described.

A Method for Measuring the Cleanliness of Milk Cans

Jensen, J. M., and Waterson, J.

Jour. Milk Tech. & Food Tech. 13(6):332-335. 1950 (Journal Article 1149 from the Michigan Agricultural Experiment Station)

A method is presented for determining the amount of residue that is contained on the inner surface of milk cans following washing with mechanical can washers. The method involves hand washing the cans with wads of cheese cloth using a detergent solution high in condensed phosphate and wetting agent content. Approximately one-half tablespoonful detergent is used in one quart of sediment-free water. Sediment tests are made of the wash water. The resulting disks are graded by comparing them with a grading chart that rates disks from 1 to 4 inclusive. Data are presented on tests made on 160 cans.

A Pressure Tester for Small Fruits and Fruit and Vegetable Tissues

BOUYOUCOS, G. J., AND MARSHALL, ROY E.

Proc. Am. Soc. Hort. Sci. 57:211-213. 1951 (Journal Article 1168 from the Michigan Agricultural Experiment Station)

A pressure tester designed for making objective measurements of the firmness of the flesh and the toughness of the epidermal portions of fruits of small size and sections or slices of processed fruits and vegetables is described and illustrated. This pressure tester has been used extensively to provide both compression and size measurements of cherry fruits in investigations under way at the Michigan Station.

Newcastle Disease and Infectious Bronchitis Neutralizing Antibody in Disease of Normal Chicken Serum

CUNNINGHAM, C. H.

Am. Jour. Vet. Res. 12(43):129-133. 1951 (Journal Article 1173 from the Michigan Agricultural Experiment Station)

Neutralization tests of Newcastle disease virus (NDV) and of infectious bronchitis virus (IBV) antigens were conducted with 100 serums from 300- to 600-day-old normal chickens using 5 eggs per serial dilution and 0.1 cc. inoculum per egg. Evaluation by the LD_{50} Neutralization Index ($LD_{50}NI$) showed that with NDV antigen the $\bar{X}$ was $10^{0.215} \pm 10^{0.0262}$ and the σ was $10^{0.262}$. With IBV antigen the $\bar{X}$ was $10^{0.389} \pm 10^{0.0376}$ and the σ was $10^{0.376}$. These data indicate that the $LD_{50}NI$ of 99.7 percent ($X + 3\sigma$) of normal serums would not be expected to exceed $10^{1.001} \pm 10^{0.0262}$ or approximately 11 neutralizing doses with NDV antigen, and $10^{1.517} \pm 10^{0.0376}$ or approximately 36 neutralizing doses with IBV antigen.

Preparation of Permanent Plastic Standards for Rapid Soil and Plant Tissue Testing

LYND, J. Q., AND TURK, L. M.

Soil Sci. Soc. Am. Proc. 15:152-153. 1950 (Journal Article 1181 from the Michigan Agricultural Experiment Station)

Plastic standards using a commercial liquid casting material "Castolite," have been developed for phosphorus as phosphomolybdic-blue, potassium as the turbidimetric cobaltinitrite test, magnesium as titan yellow color lake, and calcium as turbidimetric calcium oxalate test and also for the stearic-oleic soap solution.

These plastic standards are easily prepared and are convenient and simple to use. They are especially adapted for field testing and for student use in soil and tissue testing in the laboratory.

Detailed directions for making these standards are included in this article. Excellent duplication of color and turbidity of standard solutions may be attained by visual comparison, and the materials used are relatively inexpensive. Once colored, the hardened plastic is very resistant to fading and will remain stable with reasonable care in the laboratory and field.

The Solar-Activated Flavor of Homogenized Milk. I. Susceptibility of Individual Cow's Milk

WEINSTEIN, BERNARD R., AND TROUT, G. M.

Jour. Dairy Sci. 34(6):554-558. 1951 (Journal Article 1200 from the Michigan Agricultural Experiment Station)

Approximately 30 percent of the milk from individual cows on pasture failed to develop a solar-activated flavor following pasteurization, homogenization and 30- and 60-min. sun exposures. Homogenized milk from all of the cows on dry feed was susceptible to solar activation. There appeared to be no correlation between breed, stage of lactation and fat percentage and the susceptibility of milk to develop this off-flavor. Milk from some cows on summer pasture, upon pasteurization, homogenization and exposure to sun, yielded a nauseating flavor distinctly unlike the true activated flavor.

The Solar-Activated Flavor of Homogenized Milk. II. The Role of Oxidation and the Effectiveness of Certain Treatments

WEINSTEIN, BERNARD R., AND TROUT, G. M.

Jour. Dairy Sci. 34(6):559-564. 1951 (Journal Article 1201 from the Michigan Agricultural Experiment Station)

Data indicated that development of solar-activated flavor in homogenized milk probably was an oxidative process. Addition of ascorbic acid had no preventive effect on development of the solar-activated flavor of homogenized milk.

The addition of 25 mg. per liter of nordihydroguaiaretic acid alone, or 75 mg. per liter in combination with ascorbic acid, prevented the activated-flavor development in homogenized milk after 60 min. exposures to solar radiation.

Alpha tocopherol and hydroquinone added separately or in combination did not offer complete protection to homogenized milk against the off-flavor development.

Homogenized milk treated with hydrogen peroxide to destroy the naturally occurring ascorbic acid rapidly, prior to pasteurization and homogenization, did not develop a typical solar-activated flavor when exposed to solar radiation.

The development of the solar-activated flavor was not retarded or prevented by high-temperature (176° F. for 5 minutes) heat treatment.

The typical cooked odor noted in adequately heat-treated homogenized milk was dissipated after a 60-minute exposure to solar radiation. When the cooked flavor was produced by the addition of cysteine hydrochloride and the milk then exposed to solar radiation for various periods of time, oxidation of the sulfhydryl group of the cysteine hydrochloride was indicated by a negative nitroprusside test.

The Solar-Activated Flavor of Homogenized Milk. III. Effect of Deaeration, Surface Area of Fat Globules and Relation of the Kreis Test

WEINSTEIN, BERNARD R., AND TROUT, G. M.

Jour. Dairy Sci. 34(6):565-569. 1951 (Journal Article 1202 from the Michigan Agricultural Experiment Station)

Deaeration studies on homogenized milk indicated that the development of the solar-activated flavor resulted from an oxidative process.

Increasing the surface area of the fat globules of milk by homogenization subsequent to exposure accentuated the development of the solar-activated flavor and indicated that the surface area of the fat globules was a factor in the development of the off-flavor.

A definite correlation between a positive organoleptic taste sensation of the solar-activated flavor in homogenized milk and a positive Kreis reaction was not obtained in all cases. The identity of the constituent affected when the solar-activated flavor developed in homogenized milk was not established.

The Solar-Activated Flavor of Homogenized Milk. IV. Isolation and Characterization of a Whey Constituent Capable of Producing the Solar-Activated Flavor

WEINSTEIN, BERNARD R., DUNCAN, C. W., AND TROUT, G. M.

Jour. Dairy Sci. 34(6):570-576. 1951 (Journal Article 1206 from the Michigan Agricultural Experiment Station)

A minor-protein fraction was isolated from skimmilk after the major proteins had been removed, which was capable of being photosensitized to produce the typical solar-activated flavor of homogenized milk.

The elementary analysis, amino acid composition, isoelectric zone and the minimum molecular weight (M min.) were determined. From the data, an M min. of 70,300 was calculated along lines of orthodox organic chemistry. The determination of 12 amino acids showed that the minor-protein fraction contained the following amino acid residues: Arg_7, CyS_5, Glu_{64}, His_4, $Ileu_{20}$, Leu_{31}, Lys_{28}, Met_6, Phe_{10}, Thr_{39}, Try_3, and Val_{59} (the first 3 letters of each amino acid is used as the symbol).

Some Experiments with Seed Processing for Faster Germination of Sugar Beet Seeds (Beta vulgaris L.)

HUNTER, J. R., AND DEXTER, S. T.

Proc. Seventh Reg. Meeting, Amer. Soc. Sugar Beet Tech. 1951:39-44. 1951 (Journal Article 1214 from the Michigan Agricultural Experiment Station)

Sugar beet seedballs were extracted in water for various periods of time and sometimes subsequently dried before being placed in the germinator or various soils. No injury from soaking was evident in periods up to 72 hours, nor by up to five alternate 6-hour soaking and air drying treatments.

Wet seeds extracted for a period of not less than 4 hours should be planted. When suitably soaked but dried before planting, germination rates materially exceeded those of un-extracted seed.

Seeds wet on the surface were handled poorly in the drill. Surface drying with powdered vermiculite eliminated this difficulty.

The Germination of Sugarbeet Seedballs

DEXTER, S. T.

Proc. Seventh Reg. Meeting, Amer. Soc. Sugar Beet Tech. 1951:45-46. 1951 (Journal Article 1215 from the Michigan Agricultural Experiment Station)

The sugarbeet seedball is unsatisfactory as an agricultural seed. There may be several small true seeds embedded in the corky, nutritionally useless ball. This

cork contains a material which inhibits and prevents rapid germination. Even when this is extracted, the seedball requires for germination a soil more moist than that required by most agricultural seeds. Large numbers of seeds must be planted—and later thinned—in order to get an acceptable stand, because these seeds cannot be planted accurately, nor depended upon to germinate promptly. Although sugar content, disease resistance, etc., are important, it is well to recognize that rapid, uniform emergence of vigorous single seedlings would allow easy solution of the problems of spring mechanization.

Ethylenediamine Tetrasodiumacetate Used in Detergency

JENSEN, J. M., AND CLAYBAUGH, G. A.

Jour. Dairy Sci. 34(9):865-873. 1951 (Journal Article 1216 from the Michigan Agricultural Experiment Station)

Ethylenediamine tetrasodiumacetate was compared with condensed phosphate and alkaline salt detergents for washing quality against milk films that were air-dried, oven-dried and chlorine-treated. The ethylenediamine tetrasodiumacetate and condensed phosphate salts contributed practically equal detergency properties. Alkaline salt replacement for either condensed phosphate or ethylenediamine tetrasodiumacetate lowered film removal properties. Both salts in combination with a wetting agent produced high detergency quality against air-dried films when the detergent solution contained 10 percent added whole milk.

When the rinsing mediums included ethylenediamine tetrasodiumacetate, higher detergency was secured than when condensed phosphate salts were used, using the wetting agent as a detergent.

The Reduction of Storage Losses in Sugar Beets by Preharvest Foliage Sprays of Maleic Hydrazide

WITTWER, S. H., AND HANSEN, C. M.

Agronomy Jour. 43(7):340-341. 1951 (Journal Article 1222 from the Michigan Agricultural Experiment Station)

Preharvest foliar sprays of 2500 p.p.m. maleic hydrazide (1, 2 dihydro, 3, 6 pyridazinedione) resulted in complete inhibition of sprout and root growth of sugar beets subsequently held in storage. Sugar losses in the beets incurred during 35 days of storage were reduced from 13 percent in control lots to less than 1 percent in those harvested from plants which received the pre-harvest spray treatment of maleic hydrazide. Storage pile temperatures recorded for treated beets averaged several degrees below comparable control lots, suggesting that maleic hydrazide chemically inhibits the respiratory process.

Heat Inactivation of the Basic Amino Acids and Tryptophan

EVANS, R. J., AND BUTTS, H. A.

Food Research 16(5):415-421. 1951 (Journal Article 1223 from the Michigan Agricultural Experiment Station)

Three types of inactivation of the basic amino acids and tryptophan occurred when a complex protein concentrate, such as soybean oil meal, was autoclaved for

4 hours at 15 pounds pressure. These were 1) a reaction of the protein-bound amino acid with either glucose or sucrose to destroy the biological activity of the amino acid; 2) a reaction of the protein-bound amino acid with some other constituent of the protein to form a linkage resistant to *in vitro* digestion with trypsin and erepsin but not to acid hydrolysis; and 3) a reaction of the protein-bound amino acid with sucrose or glucose to form a linkage with properties similar to type 2. Dextrin, agar-agar, gum arabic, or soybean oil played little or no part in the inactivation. Lysine inactivation was of types 1 and 2, arginine was of types 1 and 3, histidine was of all three types, and tryptophan was 1 and 3. Lysine appeared to suffer the greatest destruction and histidine and tryptophan the least.

Methods for Staining Pollen Tubes of Apple

WATSON, DONALD P.

Stain Technology 3:273-274. 1951 (Journal Article 1234 from the Michigan Agricultural Experiment Station)

Detailed methods for dissection, clearing and staining apple pistils with Safranin O and lacmoid martius yellow are described. This clearly differentiates pale blue pollen tubes, yellow green parenchyma and bright cerise proto-xylem in the fresh material.

Parathion to Kill Fruit Fly Maggots in Cherries

SHERMAN, FRANKLIN, III, HOUK, WALLACE E., AND HARRISON, ROBERT D.

Jour. Econ. Entomology 44(5):809. 1951 (Journal Article 1246 from the Michigan Agricultural Experiment Station)

In 1949-50 in Antrim and Charlevoix counties, Michigan, wild pin cherries *(Prunus pensylvanica L.)* infested with maggots of the cherry fruit fly (*Rhagoletis* sp.) were sprayed with aldrin, dieldrin and parathion. Samples of fruit from trees sprayed with each material and untreated fruits were collected and tested for maggots. These tests showed that parathion was highly effective in destroying the maggots in wild pin cherries.

Montmorency cherries heavily infested with maggots were sprayed with 1, 2, and 3 pounds of 15-percent parathion in 100 gallons of water. At the 1-pound concentration all maggots were killed inside the cherries.

These tests appear to establish that 15-percent parathion at a dosage of 1 pound in 100 gallons may be useful to: 1) Destroy maggots in infested pin cherries, and 2) destroy maggots in cultivated cherries, thus perhaps eliminating the expensive procedure now required by state law in case of condemned cherry orchards. The results suggest that other species of fruit fly maggots may be destroyed in a similar manner.

Vitamin E Deficiency in the Lamb

CULIK, R., BACIGALUPO, F. A., THORP, F., JR., LUECKE, R. W., AND NELSON, R. H.

Jour. An. Sci. 10(4):1006-1016. 1951 (Journal Article 1265 from the Michigan Agricultural Experiment Station)

A liquid purified diet was used to study vitamin E deficiency in 32 young, suckling lambs. The source of fat in the diet of the first group was commercial

lard, while in the second group molecular distilled lard, very low in vitamin E was used.

The symptoms of vitamin E deficiency were characterized by disturbances in locomotion, stiffness, paralysis, susceptibility to pneumonia and sudden death probably due to heart failure. Blood analysis showed low α - tocopherol levels. Post mortem examinations revealed dystrophy of skeletal and cardiac muscle (Zenker's degeneration). The lesions in the heart were invariably most pronounced in the right ventricle.

Addition of α - tocopherol to the diet protected 9 positive control lambs from muscular dystrophy and greatly alleviated the symptoms of depleted animals in 3-5 days. A complete regeneration of the muscle is probably a process of long duration.

While this experimental work was in progress, the symptoms and degenerative changes of the musculature of lambs affected with so called "Stiff-Lamb Disease" under field conditions were studied. The condition of "stiff lambs" from the field appeared to be identical in every respect with the nutritional muscular dystrophy produced on vitamin E deficient diet.

The Clinical Use of Chloromycetin in Dogs and Cats

SCHIRMER, R. G., EADS, F. E., AND NEWMAN, J. P.

Veterinary Medicine 46(12):485-490. 1951 (Journal Article 1268 from the Michigan Agricultural Experiment Station)

The clinical use of chloromycetin as a therapeutic agent against several bacterial infections encountered in veterinary medicine is reported.

Indications and observations following its use are discussed. Chloromycetin, as found in this study, was 80 percent effective in 10 dogs and cats having clinical pneumonia, 78.7 percent effective in 33 dogs against the secondary invaders of canine distemper (7 dogs showing nervous symptoms were not changed by the drug), 92.6 percent effective in dogs with bacterial cystitis or nephritis, and 91.6 percent effective in 36 cats with infectious feline panleukopenia (with white blood cell counts ranging from 100 to 1300 per cu. mm. of blood), as well as in such diseases as acute infections, septicemias, metritis, and non-specific enteritis.

Some Characteristics of a Viridans Streptococcus Isolated from an Aborted Bovine Fetus

STOCKTON, JACK J., GEBHARD, WILLIAM H., AND NEU, LISA

M.S.C. Veterinarian 12(1):21-23. 1951 (Journal Article 1295 from the Michigan Agricultural Experiment Station)

Characteristics of a Viridans Streptococcus, isolated in pure culture from an aborted bovine fetus, are given. According to the classification of Sherman this organism was identified as *Streptococcus bovis*. Electron micrographs of the organism are presented. Attention is called to the possible significance of organisms other than *Brucella abortus* and *Vibrio fetus* as etiological agents of bovine abortion.

A Field Test of Several Fungicides for the Control of Powdery Mildew on Lucretia Dewberry in 1951

YOUNG, WILLIAM J., AND FULTON, ROBERT H.

Plant Disease Reporter 35(12):540-541. 1951 (Journal Article 1301 from the Michigan Agricultural Experiment Station)

In the summer of 1951 a series of sprays consisting of Ferbam, Nabam-zinc, Phygon XL, Crag 341, and Acti-dione (an antibiotic) were applied to dewberry plantings in an attempt to control powdery mildew *(Sphaerotheca humuli)*. As a pre-harvest spray only Acti-dione and Nabam-zinc showed any significant control and these effects lasted on an average of two weeks. Applied as a post-harvest eradicant, Acti-dione showed no apparent control.

Comparison of Fungicides for Control of Powdery Mildew on the Latham Red Raspberry in 1950

FULTON, ROBERT H.

Plant Disease Reporter 35(12):538-539. 1951 (Journal Article 1302 from the Michigan Agricultural Experiment Station)

Eight fungicides, including two combinations of materials, all without sticker or spreaders, were selected for evaluation as possible powdery mildew *(Sphaerotheca humuli)* eradicants. Results indicate that the sulfur treatments showed control but were too injurious to the plants. Acti-dione (antibiotic) resulted in only slight control. Tag 331, Crag 341 SC, and zineb either were of little fungicidal value for powdery mildew or were too injurious. However, Ferbam and Arathane thoroughly applied as a post-harvest spray gave decided control.

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